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Customer requirements analysis for concrete connections

Thesis submitted for approval for the degree of Master of Science in Technology

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Abstract of master's thesis

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Abstract

Customer orientation and customer-orientated methods are studied to be key elements of successful research and development. Top innovators most important goal of research and development was effectively meeting customer needs. Still, there is no clear view of who the customer is for construction product industry. The fragmented value-network of construction product makes it difficult to understand whose need should be listened and meet. From research and developments perspective, the customer is the party that use or make use of the product. Concrete connections customer from research and development perspective is then Design office, contractor and element manufacturer, who either use or make use of the product in their business.

Theme interviews were used to collect the customer requirements from design office, contractor, element manufacturer workers that are dealing with concrete connections. The found needs where separated to physical, service and symbolic aspect. Design office needs were easy and safe modeling, delivery times and availability. Design office needs also included the suitability to contractor and element manufacturer. Contractor´s primary needs were fast deliveries, deliveries arriving on time and ease of use and installation. Element manufacturer also appreciated fast deliveries as deliveries arriving on time, besides products that were easy to assembly to element molds and were not laborious. Construction industry is by nature error-prone and schedule changes are common. Product delays makes it difficult to stay on schedule and may cause seize of work. Delay of schedule binds workforce and causes additional costs to companies operating in construction industry, which explains the high importance of delivery times and reliability of delivery in the need hierarchy of design office, contractor and element manufacturer.

Keywords Concrete connections, Customer, Customer orientation, Customer needs, Value network

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Diplomityön tiivistelmä

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Tiivistelmä

Asiakaslähtöisyys ja asiakaslähtöiset menetelmät ovat tutkitusti tuotekehityksen menestyksen avaintekijöitä. Tuotekehityksessä parhaiten menestyneiden yritysten tärkein päämäärä tuotekehitykselle oli asiakkaan tarpeiden kohtaaminen. Rakennustuotealalla ei kuitenkaan ole selvää käsitystä kuka tuotteen asiakas ja kenen tarpeita tuotteen tulisi palvella. Rakennusalan fragmentoitunut arvoverkko vaikeuttaa asiakkaan hahmottamista ja kenen tarpeita tulisi täyttää kuunnella ja täyttää. Tuotekehityksen näkökulmasta tuotteen asiakas ovat tahot jotka käyttävät tai hyödyntävät tuotetta. Betonin kiinnitysosille asiakas on näin tuotekehityksen näkökulmasta suunnittelutoimistot, urakoitsija ja elementtitehdas, jotka käyttävät ja hyödyntävät tuotteita liiketoiminnassaan.

Asiakastarpeet betonin kiinnitysosille kerättiin teemahaastatteluilla suunnittelutoimistossa, urakoitsijalla ja elementtitehtaalla työskenteleviltä henkilöiltä, jotka ovat tekemisissä betonin kiinnitysosien kanssa. Kerätyt tarpeet jaoteltiin fyysiseen, palvelu ja symboliseen näkökulmaan. Suunnittelutoimiston päällimmäiset tarpeet olivat tuotteen helppo ja turvallinen mallintaminen ja tuotteen toimitusajat ja saatavuus. Suunnittelu toimiston tarpeisiin kuului myös soveltuvuus urakoitsijalle ja elementtitehtaalle. Urakoitsijan ensisijaisinen tarve oli tuotteen saapuminen ajallaan ja nopeat toimitusajat yhdistettynä helposti asennettavaan ja käytettävään tuotteeseen. Elementtitehdas arvosti myös nopeita toimitusaikoja ja toimitusvarmuutta ja tuotteita, jotka oli helppo asentaa elementtimuotteihin ja vaativat vain vähän asennustyötä. Rakennusala on yleisesti virhealtis ja aikataulujen muuttuminen on arkipäivää. Tuotteiden myöhästymien vaikeuttaa aikatauluissa pysymistä ja voi aiheuttaa työnseisauksia. Aikataulujen venyminen sitoo työvoimaa, aiheuttaa lisäkuluja alalla toimiville yrityksille, mikä selittää nopean toimitus ajan ja toimitusvarmuuden isoa roolia suunnittelutoimiston, urakoitsijan ja elementtitehtaan tarve hierarkiassa.

Avainsanat Betonin kiinnitysosat, Asiakas, Asiakaslähtöisyys, Asiakas tarpeet, Arvoverkko

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1 Introduction

The globalization and rapid technological development has set new prerequisites for successful R&D. The development times and speed of R&D has been highlighted to be important part of competitiveness of a company. The company´s ability to translate its R&D efforts to products that satisfy the customer needs is stated to be more important factor in company's competiveness than money spend on R&D (Iansiti 1997). There has been long lasting trend for moving from product orientated product development to more customer orientated product development. Collecting, managing and understanding the customer needs is thus related to success of company´s R&D efforts.

There has been lots of research for innovation management for building industry and some research concerning building product industry but not on the field of customer requirements. This study concentrates on the overall findings on product development and customer related product development studies as product development in building product industry.

1.1 Objective of the thesis

For building product industry to shift from product driven product development to more customer driven approach it needs tools for collecting and interpreting customer data in such a way that it can be used in product development. The objective of this thesis is to create tool that allows the customer perspective to be involved in the product development process of concrete connections. For the tool to be effective, certain sub-questions need to be answered:

What is the value chain for concrete connections?

From whom the customer data should be collected?

How to collect and interpret the data?

How to establish the relative importance of a need?

2 Methodology

2.1 Data gathering from interviews

The data gathering on customer requirements were acquired through interviews for the following reasons:

- Lack of earlier research in the area of customer requirements in the construction products value network
- A direct confrontation of the customer was preferred in order to get information surveys could not reveal
- The direction of discussion was not known before hand and the customer was allowed to lead the discussion in order to gather the "voice of customer"

In this research, a semi-structured interviewing method was used. Semi-structured interview has some beforehand constructed set of themes and features but the interview is also allowed to enter new themes and let the flow of the discussion dictate the course if needed (Hirsijärvi, 2001).

The interviews were recorded in order to reduce note making during the interviews so the flow of the interview would not stop. The recordings were used to re-evaluate the findings of the interviews. The records also removed the need to rely on the memory of the interviewer.

2.2 Interpreting qualitative research data

A qualitative approach is a good approach when the researched area is not researched before and the goal of research is to reveal new knowledge on the area of interest.

Analysis of qualitative data consist of two separate phases: simplification of the findings and the solving the puzzle. Simplification of the findings consist of investigating the data from a certain theoretical viewpoint at a time and gathering large number of individual small sub-findings and combining them into larger entity. The sub-findings are combined by the commonalities between them. The combining is done under the assumption that that the data consist of examples of the same phenomenon (Alasuutari, 1995).

The generalization of the findings from qualitative data is considered problematic due to limited number of samples. The qualitative often give profound information but the information is hardly general, whereas the quantitative research methods results are reliable but shallow. Thus, qualitative research methods are considered valid for new areas of research.

When the qualitative sample size is small, it is not appropriate to calculate statistic from the data.

In this study, the data was gathered from experts from different areas of the value network of product research and limited to the number interesting positions on the network.

2.3 Organizing the customer needs

First task of understanding the customer needs is to analyze systematically the information gathered on the qualities that the customer wants in a product. The raw customer information usually is diverse and usually the data needs to be sorted before the data is useful. In this study, the raw information provided by the customer was converted to requirements using a quality chart. The quality chart has three aspects that identify the product: physical, service and symbolic Iltanen (2000). Physical aspect includes the functional properties and features that the physical product has and that the customer values. Service aspect includes all the services around the product for example, customer service, technical support or availability of the product. Symbolic aspect consist of other aspects not related to physical product or services such as overall image of product and the company brand or where the previous experience of the company or other external variables.

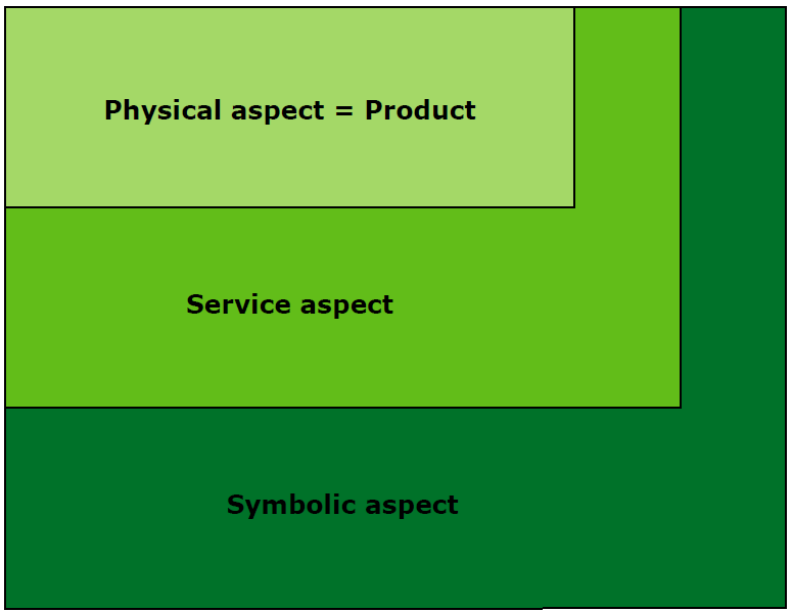


Figure 1. Product image consist of physical, service and symbolic parts (Iltanen, 2000)

A concrete connection is a typical product that combines all of the different aspects. Physical aspect consist mostly on the technical properties of the product, whereas service aspect is also important since for example

customer service and delivery times are valued in construction process. The symbolic aspect also has major importance on the construction industry where most of the constructions are built to last for decades and quality is difficulty to measure.

This distinction also allows the gathered information to be presented in more specific and organized way to help understanding the needs of the product. An example of converted customer needs in a more specific way is presented in table 1. (Aikala, 2009).

Table 1. Printing press needs related to paper

1st Level	2nd Level	3rd level
Symbolic	Evoking impressions	- Impressions related to paper are known - Tactile properties - Sound of paper - Overall visual appearance - Gloss - Whiteness - Visual evenness
Service	Service from paper mills	- Large paper selection - Flexible service - Reliability of delivery
Physical product	Information carrier	- Small details visible - Colorful pictures - Even print quality - Natural colors - Opacity
	Technical performance	- Little wastage - Good runnability on the printing press - No waviness - Color register - No loose pages - No cutting defects - No print defects - Upright magazine - Easy page turning - Paper thickness - Paper weight

One of the goals of this study is to clarify the roles of physical, service and symbolic aspect of construction connection product in customer satisfaction.

2.3.1 Evaluating the speed, ease and safety aspect of construction

The construction industry has three main development areas, make the construction process faster, easier and safer. The customer needs are thus evaluated from these perspectives in order to evaluate how comprehensive the different needs are and what are their main area of improvement.

Faster constructing is important for the construction industry since in most cases the construction has instant demand and value creation for the property owner. Faster construction time liberates the work for new projects increasing the productivity and viability of the construction industry. Products that help making constructing faster are important for the industry and have lots of groundbreaking product potential.

Ease of construction relates more to making the construction industry more error free and fluent by creating easy to use products and solutions that help reducing the amount of unwanted or unpleasant tasks in the construction process. To make the construction work easier is important to identify what task are considered difficult or unpleasant in the all level of workforce. The construction process holds a lot of potential for innovative products that solve currently unwanted tasks since construction process has changed marginally has been stagnated compared to other big industries.

The safety of construction industry is ever lasting problem since mistakes may cause human losses. Still, safety is often about finding satisfying framework where risk level is bearable since total safety is not achievable. The framework is most often created by national building codes and regulations in order to create common rules and ensure wanted safety level. Since, there is always possibility for human error in different parts of the construction process it is important to identify the parts of the process that are most vulnerable for errors, which may lead to innovations.

2.4 Limits of the study

This study have following limitations:

- The interviewees were all Finnish, and the results portray the situation in Finnish construction industry
- The constructions requirements of interest consist mostly of observations from large scale projects and constructions

3 Research and development

3.1 Innovation

Globalization has made the world smaller and international competition has set the requirements for long-term success for companies even harder. Products lifecycles are shorter and new product replace old ones faster than ever. Products lifecycles are estimated to drop over 400 percent in variety of business over the last 50 years. (Cooper 2000). The main purpose of R&D is to ensure company´s ability to compete in the developing markets of today. This is achieved by developing existing products or creating entirely new products. The winners are usually companies that succeed either selecting the right projects or succeed executing the projects. The R&D part of the company´s is also the major source of the company´s intellectual capital. It is even stated that knowledge and intellectual capital are the only sustainable sources for competitive advantage (Marti 2000). Overall, the performance of R&D is a reliable indicator of the future success of the company.

There has been lots of discussion in Finnish media about innovations after studies has shown that innovation is most important source for economic growth (Tekes, 2014). On corporate level Innovations has stated to have immediate effect on growth, success and competence. The principal definition of an innovation is a new or improved product, process or service that is made use of commercially (Trott 2011; Apilo 2007). There should also always be a novelty aspect to innovation and so all new or improved products, process or services are not considered as innovations. There is still lots of confusion about the meaning of innovation and other words originated from it. The main problem is the sloppy use of innovation related to anything new or inventive and mixing the word with invention. The commercial success divides the innovation from being just an invention. When company makes an invention and it becomes innovation only after commercial success. The diffusive use of innovation has led to undermine the original meaning of the word and has created a negative tone around and created a so-called innovation overload (Lemola 2009).

The line between innovation management and R&D is also almost thin as ice. Investopedia defines R&D accordingly: “Investigative activities that a business chooses to conduct with the intention of making a discovery that can either lead to the development of new products or procedures, or to improvement of existing products or procedures. Research and development is one of the means by which business can experience future

growth by developing new products or processes to improve and expand their operations." In Finland, the term innovation management has been synonymous to R&D making the distinction even harder (Lemola 2009). The main difference between R&D and innovation management is that innovation management can be seen to include every step of the products life cycle starting from ideation to manufacturing as far as market planning. Thus, innovation management is more comprehensive of the two and can be seen as a more holistic approach to product development. The innovation management's (on the top) and R&D (Research and Development) difference is presented in figure 2. (Vesa 2014).

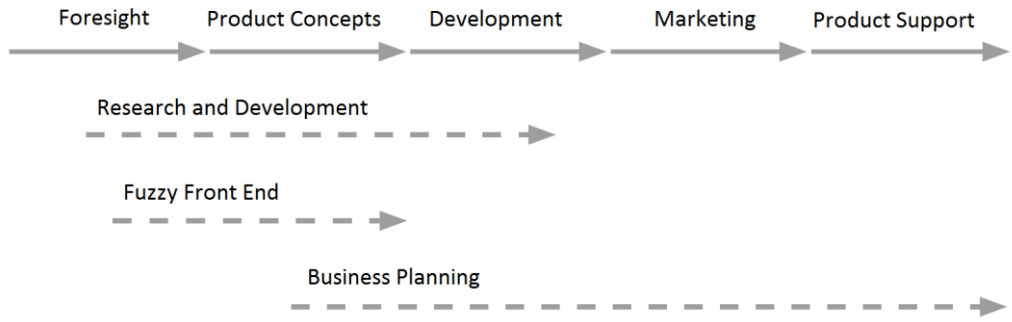


Figure 2. Innovation management process compared to R&D (Vesa 2014)

3.2 Incremental-, radical- and transitional innovation

One distinction for innovation is to separate it to incremental- radical- and transitional innovation. The main distinctive characters between are novelty, benefit to customer and the disturbance of the market. Incremental innovation is combination of many small incremental development steps that usually lead into an improved version of old product. Incremental innovations are basis for keeping up with the competition and preventing a company from falling behind from its competitors. Company´s ability to create incremental innovations sets a foundation to ensure the long-term prosperity of a business.

Radical innovations often replace existing ideas, products or processes. They have a tendency to either create previously nonexistent markets or fundamentally change the existing one. Radical Innovation can lead to massive industrial level changes what is sometimes referred as creative destruction in the marketplace (Dahl & et al. 2011). Radical innovation most often has a technological background and emerge from technologic inventions. First mobile phone is a prime example of radical innovation

replacing landline phones and creating new markets and demands that landline phones could ever achieve.

Still the distinction between radical and incremental is innovation is mostly subjective but the overall difference is presented in figure 3.

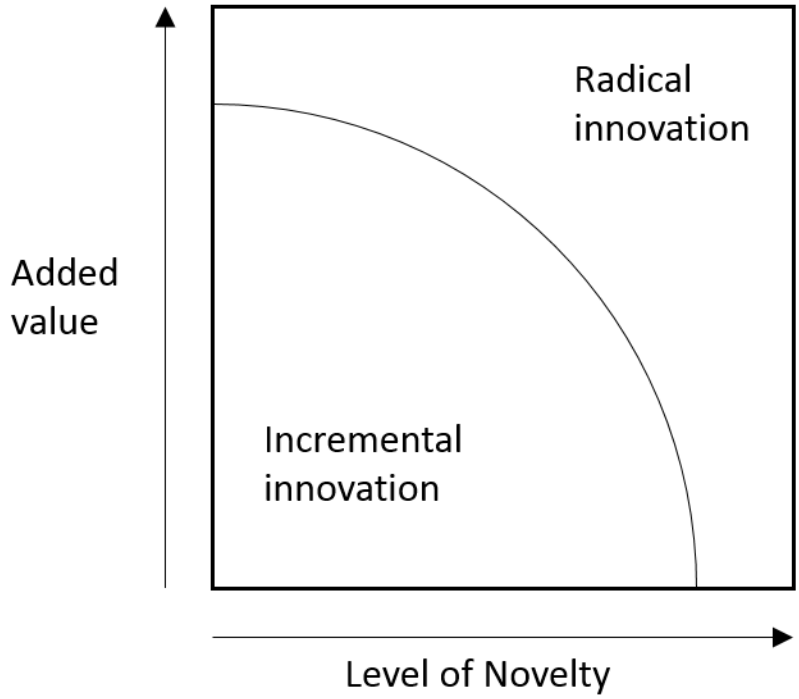


Figure 3. Radical innovation and incremental innovation relation to novelty and value

3.3 Generations of Research & Development

R&D has been studied over the years and lots of emphasis has been put on what differentiates winner from losers and what are the common drivers of successful R&D. The success factors and managerial approaches has been changing throughout the years depending on the economic conditions and ever tightening competition. To evaluate the current emphasis of R&D it is important to understand the evolution of R&D and what where the context and drivers that led the transition between different generations of R&D.

The perspective of R&D process has changed throughout the years due to economic changes and globalization. Nobelius (2004) separate the different generations of R&D and their corresponding characteristics and context into five different generations.

The 1st generation (1950 to mid- 1960s) is descript according to Zhao (2003) as technology-push dominated where scientific breakthroughs where the main source for new products. During that time, many new industries

emerged and most of the products produced where sold (Rothwell 1994). The interaction of R&D unit with between other units of the company is seen lacking and the R&D is been lead without a long-term strategy.

The 2nd generation (mid- 1960s to early 1970s) had increasing competition due to supply and demand matching better than in the 1st generation. Since the increased supply of competing products, the focus from R&D shifted towards marketing for increasing sales (Rothwell 1994). The typical R&D is led by the short-term market demand and is seen as the opposite of research dictated 1st generation. The ideas for development emerged from market demand and the business side guided heavily the R&D efforts (Von Hippel 1976).

The 3rd generation (mid- 1970s to mid- 1980s) is shaped by saturated demand and high rates of inflation which shifted the focus to cost control and cost reduction (Rothwell 1994, Miller 1999). The R&D process was also in review for cost efficiency and portfolio view was created to balance the risk-reward probabilities of different R&D projects and more linked to the corporate strategies (Nobelius 2004).

The 4th generation (mid-1980s to mid-1990s) is characterized by increasing speed of product development and focusing more on the customer. The emerge of new product development process, parallel and integrated R&D activities were highlighted as key factors for succeeding when aiming for speed. Product orientation changed to more customer focused and instead of focusing only to products itself the perspective was extended to whole business concept (Iansiti 1997).

The 5th generation (mid-1990s – onwards) new challenges emerge as global competition, rapid technological changes and need for sharing heavy investments (Rothwell 1994). These challenges set new requirements for R&D and thus they need to operate with the business environment. The business environment for construction industry would for example include distributors, “customers”, suppliers, contractor, design office etc. The speed is not the only issue in product development but the ability to control the speed and be timely, leading to separate the more uncertain research activities from product development.

R&D Generations	Context	Process Characteristics
First generation	Black hole demand (1950 to mid- 1960s)	R&D as ivory tower, technology-push oriented, seen as an overhead cost, having little or no interaction with the rest of the company or overall strategy. Focus on scientific breakthroughs.
Second generation	Market shares battle (mid-1960s to early 1970s)	R&D as business, market-pull oriented, and strategy-driven from the business side, all under the umbrella of project management and the internal customer concept.
Third generation	Rationalization efforts (mid-1970s to mid-1980s)	R&D as portfolio, moving away from individual projects view, and with linkages to both business and corporate strategies. Risk-reward and similar methods guide the overall investments.
Fourth generation	Time-based struggle (early 1980s to mid-1990s)	R&D as integrative activity, learning from and with customers, moving away from a product focus to a total concept focus, where activities are conducted in parallel by cross-functional teams.
Fifth generation	Systems integration (mid-1990s onward)	R&D as network, focusing on collaboration within a wider system – involving competitors, suppliers, distributors, etc. The ability to control product development speed is imperative, separating R from D.

Figure 4. Description of five generations of R&D processes (Nobelius 2004).

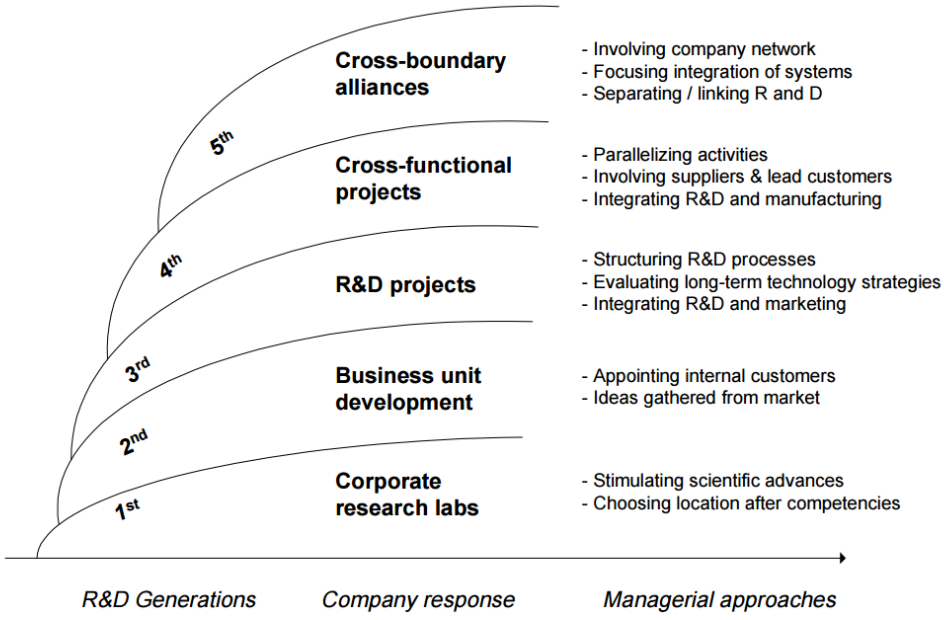


Figure 5. Visualization of five generations of R&D management, related company responses and examples of associated managerial approaches. (Nobelius 2004).

3.4 Success factors of R&D

Performance measure of R&D should highlight the main goal of R&D (to ensure the company´s competiveness and ensure its financial well-being). Still the company´s competiveness and financial well-being may be an outcome of various other reasons other than the work done by R&D. Various studies usually handle the problem of varying competition and industrial differences by comparing businesses in the same industry and benchmark their performance. According to Cooper (2006) the top-notch way to measure the performance and the productivity of R&D it is output (new product sales and profit) divided by the input (the research and development cost and time). The need to constantly develop new products or improve existing ones is backed by Cooper (2013) statements on American Productivity & Quality Center (APQC 2003) benchmarking study that products developed in last three years' account for 27.3 percent of company sales. According to the same APQC, many new products fail, only 53.2 percent of new product development projects achieve their financial goals and as few as 44.4 percent developed in time.

A study by Little (2005) surveyed globally over 800 companies across the globe and collected their insights as innovators and divided them by their innovation performance to top, regular and poor innovators. The study separates the best innovators according to their innovation efficiency factor that resembles the productivity of R&D. The innovation efficiency factor is calculated using the share of total sales generated by new products divided with the share of total sales spent on R&D.

$$Innovation\ effiency\ factor = \frac{Share\ of\ total\ sales\ generated\ by\ new\ products}{Share\ of\ total\ sales\ spent\ on\ R\&D}$$

$$Share\ of\ total\ sales\ generated\ by\ new\ products = \frac{Sales\ of\ products\ less\ than\ 5\ years\ old}{Total\ sales}$$

$$Share\ of\ total\ sales\ spent\ on\ R\&D = \frac{Expenses\ of\ R\&D}{Total\ sales}$$

The companies were divided by their industry and the best innovators were the top 25% and the poor the lowest 25% of companies measured by the innovation efficiency factor in their industry.

The study found out that the best innovators get on average more than 10 times higher returns from their innovation investment. Construction and equipment industry top innovators get around 5.9 times greater results from their investments than the poor innovators. Results of the study presented in figure 6.

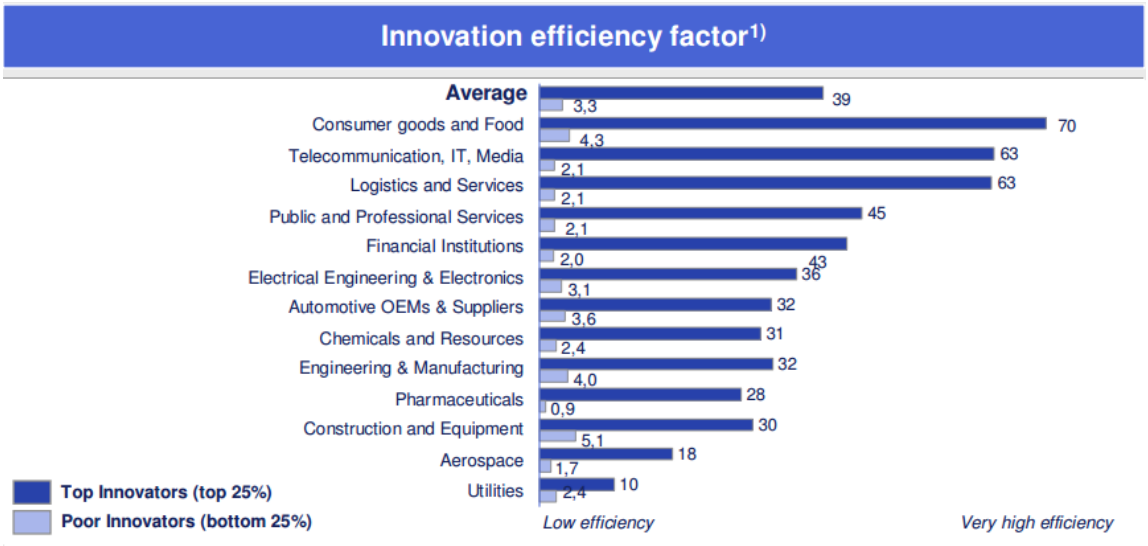


Figure 6. Different industries and the performance comparison of top and poor innovators (Little 2005)

What was also found that the share of total sales generated by the new products (new products were defined to be products less than 5 years old) was on average 2.5 times higher in the top innovators compared to the poor innovators. This point out the fact that the most efficient innovators were also able to create most new sales. The share of total sales generated by new products had 2.1 times higher in the construction and equipment industry. The results of the presented in figure 7.

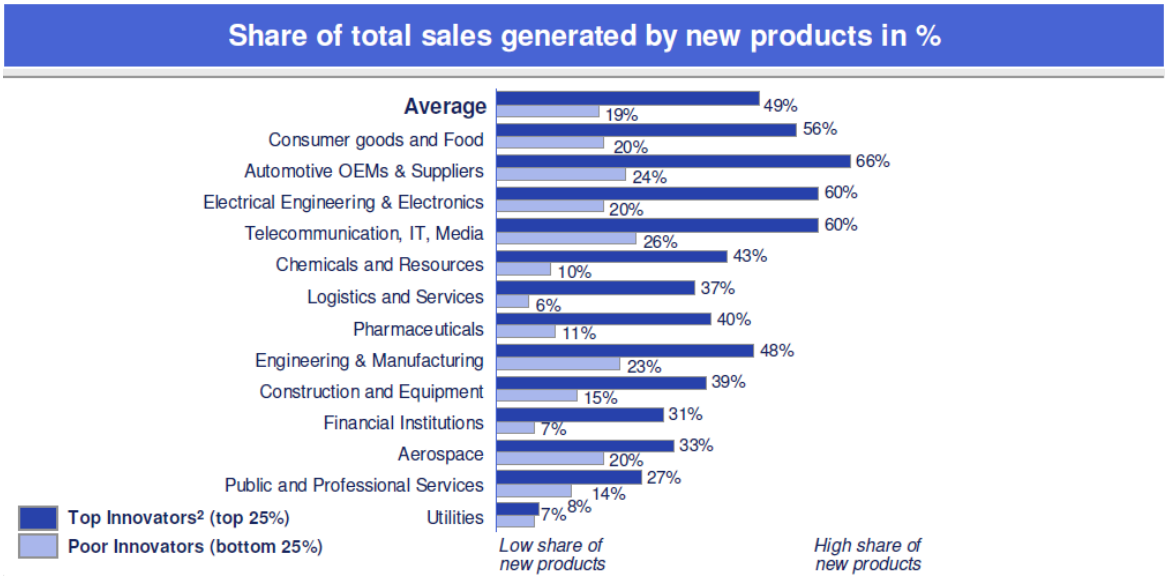


Figure 7. Top and poor innovators share of total sales generated by new products (Little 2005)

More interestingly, the innovation study also examined the top 25% of the companies and their response what drive their success. When they were asked about their goals of innovation, a goal for effectively meeting the

customer needs was highlighted as the most important goal of innovation. Direct customer contact was also stated by Little (2005) to be essential component of innovation excellence and also a source for market intelligence.

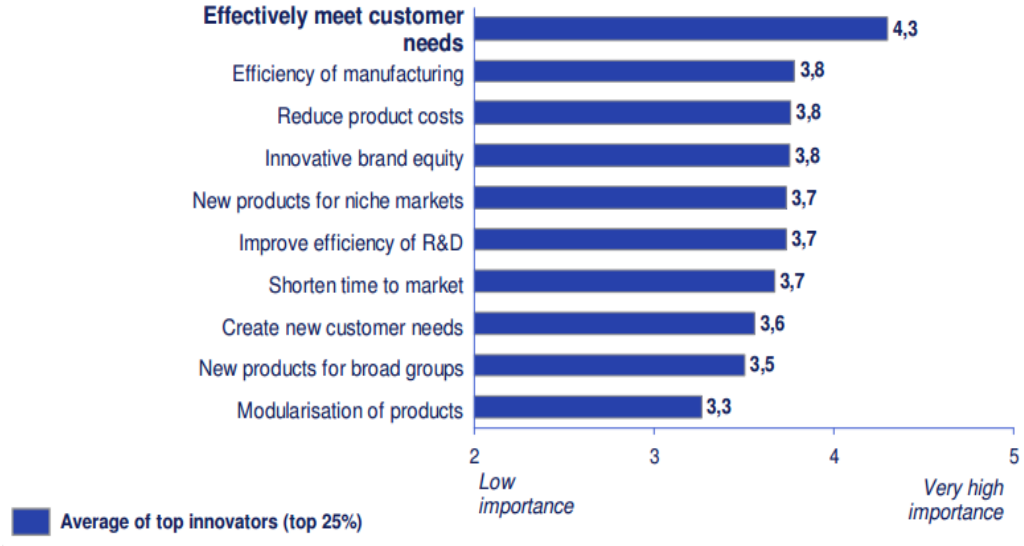


Figure 8. Top innovators innovation goals measured by their importance

The Innovation survey conducted by Little (2005) still gives few answers to linkage between spending on R&D compared to the performance of R&D. Do the best performers also spend the most out of their revenue to the R&D? This is an interesting and important question whether the companies fare better by simply increasing their spending on R&D. A study conducted by Terwiesch & Ulrich (2009) was composed to answer this question and enlighten the linkage between spending and performance. The study evaluates competing business performance and spending in the computer industry. The performance of R&D was evaluated by average growth in five-year time span and the spending as share of revenue to spend to R&D. Terwiesch & Ulrich (2009) used a diagram with productivity as the x-axis and performance as the y-axis and plotted the companies according to their values x- and y-values. If the spending was to correlate with the productivity, the studied companies should create a linear distribution to the chart. The result of the study is presented in figure 9 (Terwiesch & Ulrich 2009).

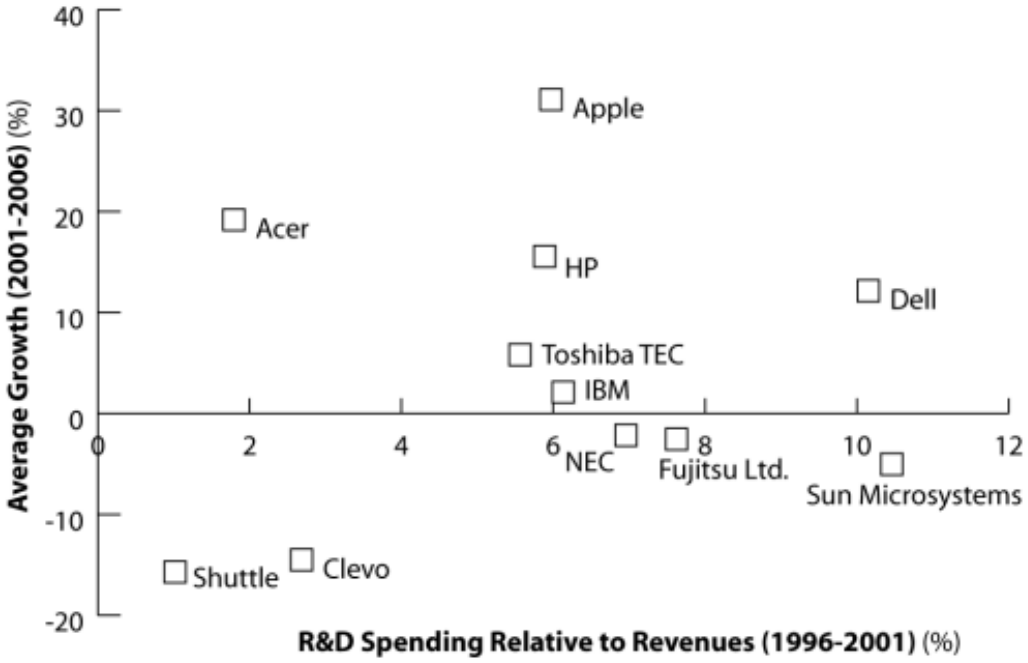


Figure 9. The relationship between R&D spending as a percentage of revenues and revenue (Terwiesch & Ulrich 2009)

As is explicit in the figure 9, the spending on R&D seems to have very little effect on average growth of the company. It seems like the best performances have a better understanding how to develop their company, which seems not be related to the spending of R&D. The lack of correlation between spending and productivity is not unique to computer industry, similar findings have been evident in pharmaceutical, chemical and automotive industries where large investment have not been payed off as higher growth or better margins (Terwiesch & Ulrich 2009). Amplifying the fact, that spending more on R&D is not a key for successful business or ensure financial returns.

Terwiesch & Ulrich (2009) state that the ability to find exceptional opportunities creates exceptional value and is aspect in order to improve R&D performance. To find these exceptional opportunities, the ability to find large amount of ideas is highlighted by Terwiesch & Ulrich (2009). The large number of ideas is then proposed to be estimated by using harsh and systematic tournament to separate the best from the rest. The gathering of large amount of ideas and the breakdown of them is proposed to ensure that only the best ideas or concepts are left for further development, giving a solid foundation for new R&D projects.

Since a common way to evaluate the performance of R&D is either sales of new products or growth of the company in relative time span (Cooper,

Terwiesch & Ulrich, Little). Success of R&D is highly related to ability to innovate, or in other words ability to create new products. To most comprehensive study on new products success has been made by Cooper (2013) combining numerous studies of why new products succeed, comparisons of winners and losers, and benchmarking best performing businesses Cooper (2011) has been able to distinct eight critical success factors for new products success:

1. **Striving for unique superior product**
   Cooper defines a superior product accordingly "A differentiated product that delivers unique benefits and a compelling value proposition to the customer or user". The common features of superior product are great value for money, excellent quality compared to competing products and the benefits are highly visible and meeting the customer needs. Ability to develop a superior product is supposed to be the number one driver for profitability of new products.
2. **Creating market-driven products and building in the voice of customer**
   A thorough understanding of the customer needs, competitive situation and the nature of markets are essential factors in new product development. Market-driven approach helps to ensure the product is developed to appealing markets. Voice of customer is respectively used for creating a thorough understanding of customer needs and priorities. Leaving the customer out product development or either underestimating the importance of needed market assessments is the main reason why new products fail.
3. **Pre-Development work**
   Focusing more on the work before the actual development and design phase of a new is critical for success. Successful firms tend to use twice as much time and money on the front-end activities of the project as their less successful counterparts. Most of the companies' rush into technical oriented task and pay the price later on with interest, most companies recognize this as their weakness. There is also a common fear of increasing the project length, but this happens to be the opposite of things since good pre-development work is a way to reduce development times.
4. **Sharp, early, stable and fact-based project and product definition**
   The worst time waster of product development project is unstable product specs and constantly changing project scope. This effects the

technical people having difficulties on achieving set goalposts, timelines and targets for the project. Extensive product definition helps to meet the object of the project and to minimize irrelevant work. Definition of the project should consist, definition of the project scope and target market, description of the concept and intended benefits, market position and target price and finally a list of products features attributes prioritized specifications.

5. **Spiral development – Build, test, feedback and revise**

   Spiral development is a fast paced iterative development process that ensures the customer/user is involved throughout the new development process. It is based on constant test and feedback loops that ensure the developed project fits the customer needs. Creating a new product takes time and sometimes the preferences or observations of customer needs change during the development time. This is a problem when development phase of the product is rigid and linear and can´t adapt to any new information after the pre-work. Even when the pre-work is done properly creating a product in a vacuum, where the customer or user is neglected in the development phase creates a major risk for the success of product.

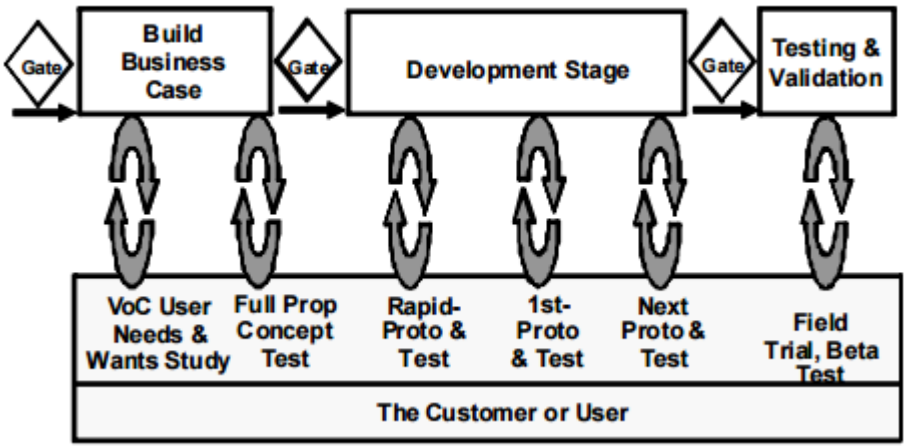


Figure 10. Spiral product development process (Cooper 2013)

6. **Global orientation**

   In global markets the R&D play primary role in keeping competitive advantage due to extremely intensive competition. Multinational firms that have global approach to their new products outperform those that concentrate on their home markets (de Brentani and Kleinschmidt 2004). Similar products that are designed only for domestic markets and after that adjusted to export markets fare worse. Global orientation is to comprehend that the market is

international and try to meet the international requirements instead of just domestic ones. Global still don´t necessary mean the whole world and separating different global markets for example western and eastern is necessity for the success.

7. **Planning and resourcing launch**
   Even the best products in the world don´t sell if not enough people know about the product and its benefits. There are countless examples of good inventors that have failed with their product and are unable to capitalize their invention. The products don´t sell themselves and the marketing of the product should start early in the product development phase. The proper launch should include the personnel executing the launch and ensuring commitment from the sales department for the product. The importance of proper launch is easy to overlook on even though it has direct link to the profitability of the product.
8. **Speed**
   Speed is vital in highly competitive markets and in any market, one of the most important things since being first is gives tremendous asset to the business. The products that hit the markets first or even creates one faces less or even no competition and achieve higher profit margins compared to products without any novelty to them. Reducing development cycle is a tempting goal for R&D, but it is still a double-edged blade, if the level of quality drops, it most likely will only cause failure than success. Even when the speed is so important it will not compensate for the negative aspect of bringing unfinished or inadequate product to the market.

One important observation is to notice that almost all of the critical factors presented emphasize customer orientation. In addition, the top-innovators in the innovation study (Little 2005) rated effectively meeting customer needs as their main goal for successful innovation. This leads to a statement that the customer is the key for success in R&D and should be involved in every phase of R&D one way or other.

3.5 Sources for innovation

Innovations are critical for the long-term competiveness of the company. Novel products have higher profit margins and innovating allows the company to maintain competitiveness in the end. Understanding the origin of innovations and typical sources for innovation is important. In addition, every company needs to resolve where and how they are going to gather

and manage the ideas for innovations. Innovation managed is a common managerial challenge and inspirational innovation environment is stated to be important factor when gathering ideas internally. Majority of the studies suggest that customers are the main source of new product ideas. Still about half of the innovation opportunities comes within the company and other half from customers and other external sources (Ulrich & Eppinger 2012).

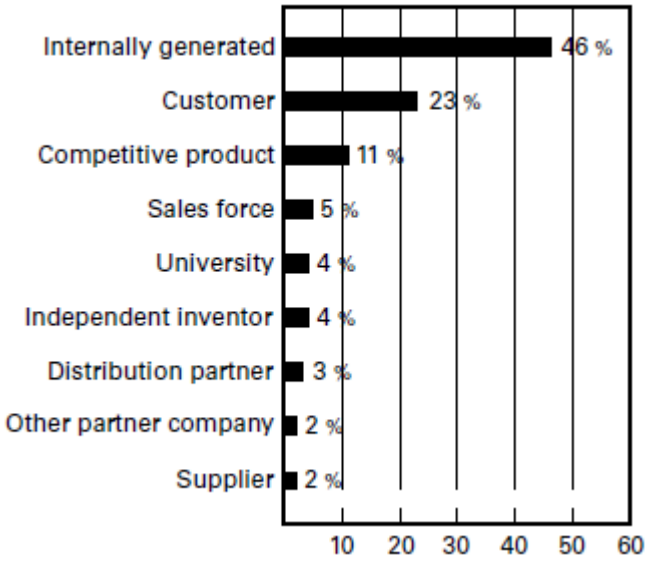


Figure 11. Sources of innovations (Ulrich & Eppinger 2012)

Von Hippel (1988) has divided the Innovation source into three categories: user, manufacturer and supplier. The user is someone who benefits from using the innovation, the manufacturer is someone who benefits from manufacturing the innovation and the supplier is someone who benefits from supplying material for manufacturing the innovation. Depending on perspective, the company can be either user, manufacturer or supplier. For example, if the product is real estate the user is the owner of the house, manufacturer is the builder and the supplier is material provider. The roles change when the distinction is made for construction products where the user is the builder, manufacturer is the product manufacturer and the supplier is the product material provider. Using this simple distinction, von Hippel (1988) studied the innovation sources for different type of products in different industries. What was found out was that the users were the main developers of innovation in most cases.

Innovation Type Sampled	Innovation Developed by: User	Manufacturer	Supplier	Other
Scientific instruments	77%	23%	0%	0%
Semiconductor and printed circuit board process	67	21	0	12
Pultrusion process	90	10	0	0
Tractor shovel–related	6	94	0	0
Engineering plastics	10	90	0	0
Plastics additives	8	92	0	0
Industrial gas–using	42	17	33	8
Thermoplastics–using	43	14	36	7
Wire termination equipment	11	33	56	0

Figure 12. Innovation developers in different types of products (von Hippel 1988).

Important notion is how much variation there can be between user and manufacturer developed innovations in different fields. It points out that understanding the main source of innovations is beneficial for the company to understand. (Von Hippel 1988)

Main sources of innovation are (Trott 2011):

- Existing products are common platform for further development of new product families with different features or improved features that lead to a new product.
- Benchmarking and competitors' products can create a need for developing products with more similarities. Purchasing and examining competitors is a common source for new ideas and knowledge of what kind of products the market is flooded.
- Businesses R&D organization task is monitor the technological development in the field of industry in order to find new product possibilities or ways to developed
- Unutilized patents and licensing options are sources for innovation. Utilizing these sources demands constant mapping in order to work efficiently
- Customer, supply chain and retailers are important source of innovation. Usually they are passive, but usually are ready to tell ideas if they are asked and involved.
- Sales department has a key role inside the company. They are directly linked to the customer and possess an understanding what the customers´ value. Sales personal is needed to motivate to keep

in mind anything interesting comes up since usually their focus is not on the development of products.

- Management has role in creating innovation friendly environment and a role in creating ones. In order to provide innovations, the management should have a good knowledge of the industry and involved technology.
- Brainstorming and systemic use of collecting product ideas.

Whether the ideas are generated internally or externally, it is more important to understand where the most useful ideas emerge and how. Having an understanding of different sources for ideas ensures that all potentially valuable sources are cultivated. Same logic goes with different methods to gather ideas for innovations, if the methods used are not effective it will weaken the changes of finding reliable way to create proper ideas. To understand from whom and how the best ideas are found Cooper (2010) has studied different methods that are used to systematically gather new ideas for innovations

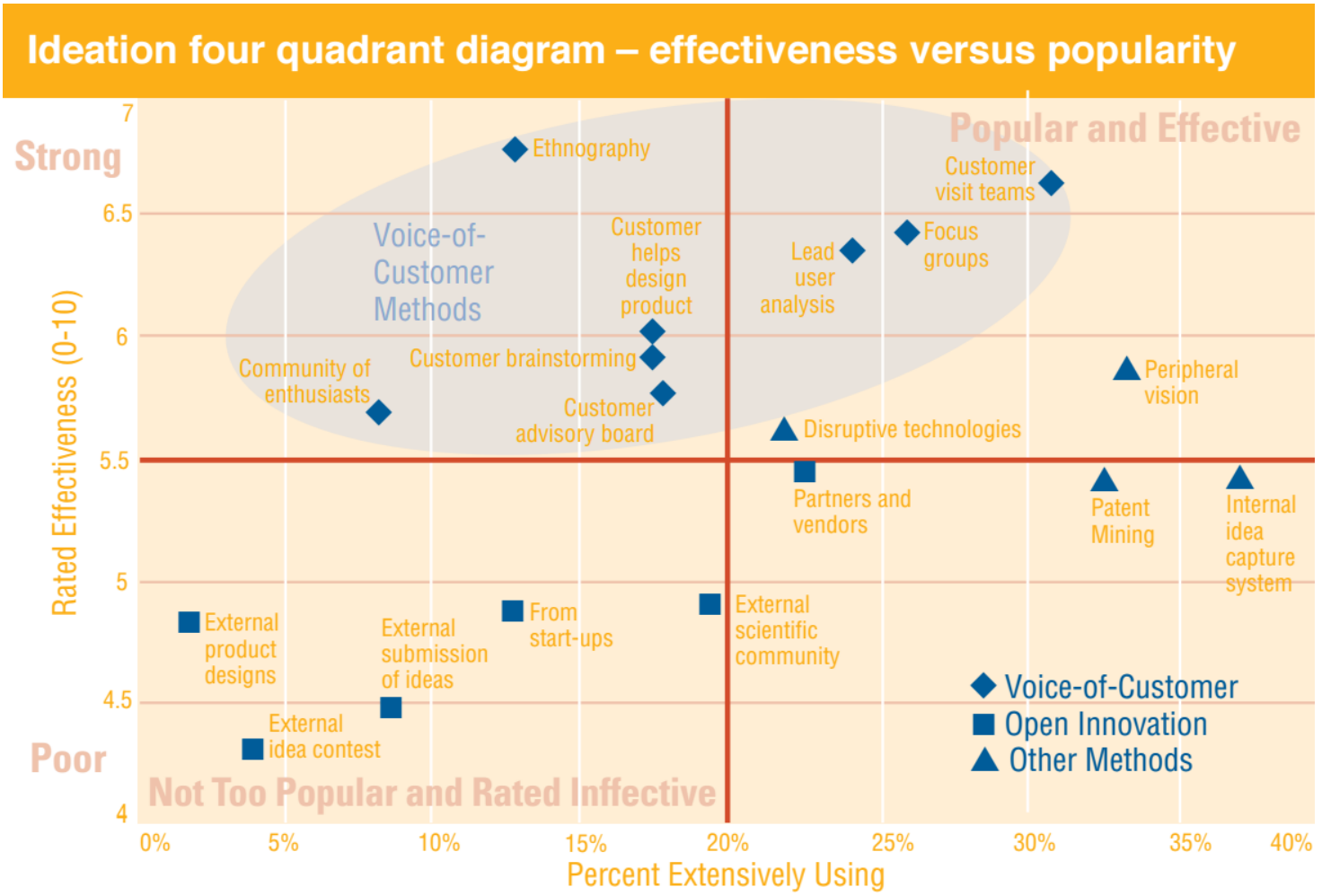


Figure 13. Comparison of usage and effectiveness of idea gathering methods (Cooper 2010)

Different methods for gathering ideas for innovation (Cooper 2010):

Voice of Customer methods:

1. **Ethnographic research**
   Observing customers for extended period of time in order to watch and learn as they use or misuse the product, in order to achieve insights and depth knowledge of the unmet and unarticulated needs.
2. **Customer visit teams**
   Customer or user visits with in-depth interviews to find user problems, needs and wants for new products.
3. **Customer focus groups**
   Focus groups are gathered to seek and discuss their problems, needs and wants. Moderator focuses on that the discussion helps user dig deeper in their problems.
4. **Lead user analysis**
   Emphasizes to find customers with the most experience, knowledge and thus potential for innovative ideas and involve them in finding

problems and needs that ordinary customer is unable to articulate or understand.

5. **Customer helps design the product**
   Customers are invited to help and design a new product (fit only certain category of products).
6. **Customer brainstorming**
   Gathering group of users and setting up a brainstorming session to come up with new product ideas.
7. **Customer advisory board**
   Advisory on problems and new product needs and at the same time helps maintaining good customer relations.
8. **Community of enthusiasts**
   A community is gathered around a forum where enthusiasts' users can discuss and share their problems and ideas about the product. (Highly product depended)

Open innovation methods:

9. **Partners and vendors**
   Extracting ideas from outside the company partners and vendors. Additional benefit may be new technical capabilities from the partner or vendor.
10. **External scientific community**
    Approach to seek new ideas and technological solutions from scientific and technological communities.
11. **Scanning small businesses and start-ups**
    This approach accesses small or start-up businesses to get ideas from them. Included with a problem where to find the right companies.
12. **External product design**
    Encourage the external world enabled by internet to provide you with developed products.
13. **External submission of ideas**
    Encourage the external world to provide you with new ideas. Time consuming and product depended.
14. **External idea contest**
    Hosting an idea contest with a prize in order to encourage good ideas.

Other methods:

15. **Peripheral vision**
    External world is evaluated to identify trends, threats and potential new products. This helps the companies not being surprised by major external events or trends that can involve major opportunities.
16. **Disruptive technologies**

Since disruptive technologies poses threat to well-established businesses and great opportunity to those who see the change. This method monitors new-technologies and possible new products enable by the technology creating new product ideas.

17. **Patent mapping**
    Using mapping or mining others´ patents in order to identify potential areas for new products. This method has problem generating new ideas.
18. **Idea capture internally**
    Involving own employees and gather and evaluate their ideas. Usually the un-effectiveness is the reason of a poor management and system to handle the ideas.

According to the study, voice of customer methods are rated much more efficient than open innovation methods. The open innovation methods should fare better in environments were the user/customer have a clear incentive on developing product modifications (Von Hippel 1988). Other more strategy based methods fare better than open innovation but still lack the effectiveness of voice of customer methods. The most interesting methods provided by the study are the most popular and effective ones. Ethnography is rated to be the most effective method even when by nature it is time consuming. Ethnography is also a fitting method in the construction industry where most of the work is done under circumstances that can be easily monitored by camping. Customer visit teams, focus groups, lead user analysis and peripheral vision formed an interesting group as highly used and effective and should be potential for idea gathering.

3.6 Customer orientated product development

The foundation of customer orientated product development it is the customer itself and ability to create and serve the customer. The main objective of customer orientation is to develop a profound knowledge and understanding about the customer needs and wants and the ability to meet them. The customers' needs and wants sets a direction to the whole development project and the customer is utilized in all of the phases of the product development project.

The customer orientated product development values novel findings of the customer needs that are discovered. Those findings can be used to create products that create more value to the customer than existing products. A need is not a uniform notion and can be divided multiple ways depending on the context of use. Gheorghe & Sandovici (2008) provide a fitting

classification for different needs within the framework of this thesis and topic of product development:

- **Known and articulated needs (expressed needs)**
  A need that a customer can fully understand and communicate to the researcher in an understandable way. Desirable situation but also unusual.
- **Known and unarticulated needs (unexpressed needs)**
  Situation where the customer knows his/her needs but is unable to transfer the information to the researcher. The inability to articulate the need is often caused by lack of technical knowledge, fear of looking stupid, withholding purchasing information or think the need cannot be satisfied.
- **Latent needs (unconscious needs)**
  Latent needs are something that the customer is not aware of and so have no means to describe them. They can be every day difficulties that are so familiar that they are not experienced as a difficulty, just common way of doing things. Latent needs may be even more important than explicit needs in determining customer satisfaction (Ulrich & Eppinger, 2012)
- **Future needs**
  Needs that don´t exist yet, but are going to emerge because of inevitable technological development.

Customer orientated product development can either result in incremental or radical innovation. The probability of creating a radical innovation increases if novel and latent needs are exposed during the product development project.

The customer orientation emphasizes having the designers to spend time on the users' environment in order to relate to the customer especially before the design starts. Even though, this approach is time consuming it is found by Smith (1998) to save time due to decreased need for re-design work. Customer orientation also helps to achieve important goals related to new product development according to Ulrich & Eppinger (2012):

- Ensure that the product is focused on customer needs.
- Identify latent or hidden needs as well as explicit needs.
- Provide a fact base for justifying the product specifications.
- Create an archival record of the needs activity of the development process.
- Ensure that no critical customer need is missed or forgotten.
- Develop a common understanding of customer needs among members of the development team.

3.6.1 Customer, market and product orientation

In order to understand the customer orientation, it is beneficial to evaluate it towards it "predecessors" the product orientated and market orientated product development. The product oriented product development starts with so-called technology push were new technology is starting point of the product development where as in the market pull the needs gathered from market place sets the direction to R&D. (Trott 2011)

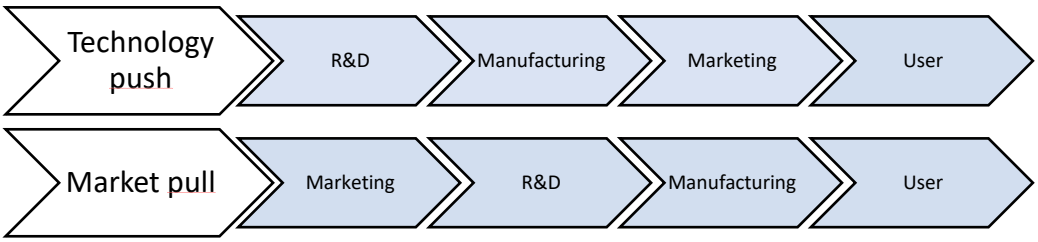


Figure 14. Product and market orientated product development processes (Trott 2011).

Product orientation concentrates on creating new products that do new things or have new features usually enabled with a new technology. The product is developed with an internal confidence of the product and in its ability to provide new value for the customer. The product-oriented team usually has a default understanding what the customer wants or needs from the product and the customer is excluded from the development project. The success of the product then relies heavily on the insight of the development team, which increases the products risk of not fitting the market. Also, risk for problematic design mistakes for user increases when the focuses are on the features. (Gaskin 2013)

Customer orientation have had a lot of critique when it is considered an equivalent or counterpart of market orientation. The main critique is that customer orientation or market driven approach leads to bland products and is unable to produce radical innovation (Martin & Faircloth, 1995). It is true that market orientation and customer orientation in some level are similar and share some inconvenience and problems (Trott, 2011; Smith, 2008):

- **Customers are poor at articulating their needs**
  More than often customers have difficulties to express their needs or can articulate just their existing basic needs. The market orientation thus misses latent or hidden needs and thus ability to create novel products.
- **Customers are poor at evaluating novel products**

Market research methods work the best when the customer can relate to the product. The customers' ability to evaluate the value drivers of new products is questioned.

- **The public don´t know what is possible**
  The customer lacks the foresight and ability to know what is possible, leading only to incremental development. Instead, focus should always be on leading the customer instead of be led by the customer.
- **The consumer research is valid only in one point in time**
  Consumer research can only tell what people did or wanted in specific time and context. The findings might not be correlating in different times or context. Outdated research might even be harmful to development process.
- **Customer might not know the best**
  There are numerous examples were the market research has falsely predicted that the product will be a failure but they still ended up being a huge success and in contrast there are examples of products that should had been a success but ended up being an utter failure.
- **Market research discourages discontinuous new products**
  Discontinuous new products are the main source for more radical and major innovations. Market research is stated to discourage development of discontinuous products and so decrease the ability to create innovations.

Still, the most of the critique that customer orientation has it is when it is considered as equivalent of market research. The customer orientation is separate concept and could not be seen as solely market orientated or product orientated approach, even when has lot of similar features of market orientation. Still it has been popular to label it as market orientated, even when customer orientation is more comprehensive concept. The distinction between market or product orientation is becoming stale and Trott (2011) argues that the focus should shift onto understanding innovation.

The emphasis of customer orientation is the deep understanding of the customer needs. The actual customer itself might be unable to articulate its needs or give unreliable information. When identifying these kind of silent or latent needs different kind of methods are needed to collect the actual needs of the customer. Instead of criticizing the customers' ability to

articulate his needs, the focus should be on emphasizing with the customer and understanding the needs from his point of view.

The most difficult part of customer orientation is to know what kind of and how far-reaching research is needed to be done in order to capture enough conclusive understanding of the customer. Most of the time it is subjective if enough profound understanding of the customer is achieved. With a deeper understanding of the customer needs and mindset, it becomes easier to exploit any new or existing technology to serve those needs. The ability to relate to the customer and find latent needs or understand existing one is found to be an important part of innovations.

The customer-orientated approach is not linear and when novel or latent needs are discovered it can create a new perspective and start more product-orientated project to create the product. It is found out that a customer is typically a poor evaluator of new with novel product properties. When the product properties rely on deep understanding of the customer, superficial notions about the product can be neglect. Still it doesn´t mean that the customer is not valuable resource developing the features and preventing bad design solutions.

The benefits of being customer orientated still goes throughout the whole R&D process and not just idea creation. The customer is an integral part of the entire product development process: scoping, product definition, development, validation and beyond that (Cooper, 2006).

3.6.2 Emphatic design

Empathy is defined to be “the ability to be aware of, understanding of, and sensitive to another person’s feelings and thoughts without having had the same experience” (Battarbee & et al, 2014). Emphatic design is an approach directed towards building this deep emphatic understanding of the users by observing their use of the product in their everyday lives (Postma, Zwartkruis-Pelgrim, Daemen & Du, 2012). The ability to observe the user and the actual use of the product in the user´s own environment provides a unique and rich source of information. The information is retrieved from empathy for the user which is defined as “an understanding of what it feels like to be the user, what the user’s situation is like from his/her own perspective” (Wright & McCarthy 2008). The researcher’s ability to relate and connect with the user is invaluable for the success of the method. The techniques of emphatic design concentrate on gathering, analyzing and applying the information obtained from observing the user (Leonard, 1998). This holistic approach helps to identify latent and unarticulated needs that

would be otherwise difficult to discover. Emphatic design is thus most useful in the early phase of the product development where opportunities and products demands are identified. According to Postma and et al. (2012) the design for user experience has four principles that lie in the heart of emphatic design:

1. Balancing the rational and emotional approach in building understanding of user experience. Understanding people´s experience requires a rational and emotional approach and emphatic design combines those with observation of what people do with interpretations of what people think, feel and dream, combining rational and emotional aspects together.
2. A need to make empathic inferences about users. People´s feelings, experience, and thoughts are best understood through empathy and from their own perspective. The ability to interpret of what people think and feel helps envisioning possible improvement of future use of the product.
3. Emphatic design prompts continuous development and check of created understanding of user. Involving users as collaborates in NPD, so that researchers and designers can gradually develop the product, check, and test their understanding with a constant dialogue with users.
4. Engaging the design team members as multi-disciplinary experts in people research. The different skills, expertise and thinking is required related to social science, design and technology.

The emphatic design is a complementary method in a quest of finding and understanding the customer and is not created in order to replace traditional market research. The origins of the emphatic design are in the late 1990s, when designers experienced challenges with designing products to large connected eco-systems that affect users' behaviors and experiences beyond the individual product or service (Postma & et al, 2012; Battarbee & et al, 2014). The observation is the foundation of emphatic design instead of inquiries that are used by traditional market research. The emphatic design can generate different types of information that traditional market or product research cannot provide (Leonard, 1997):

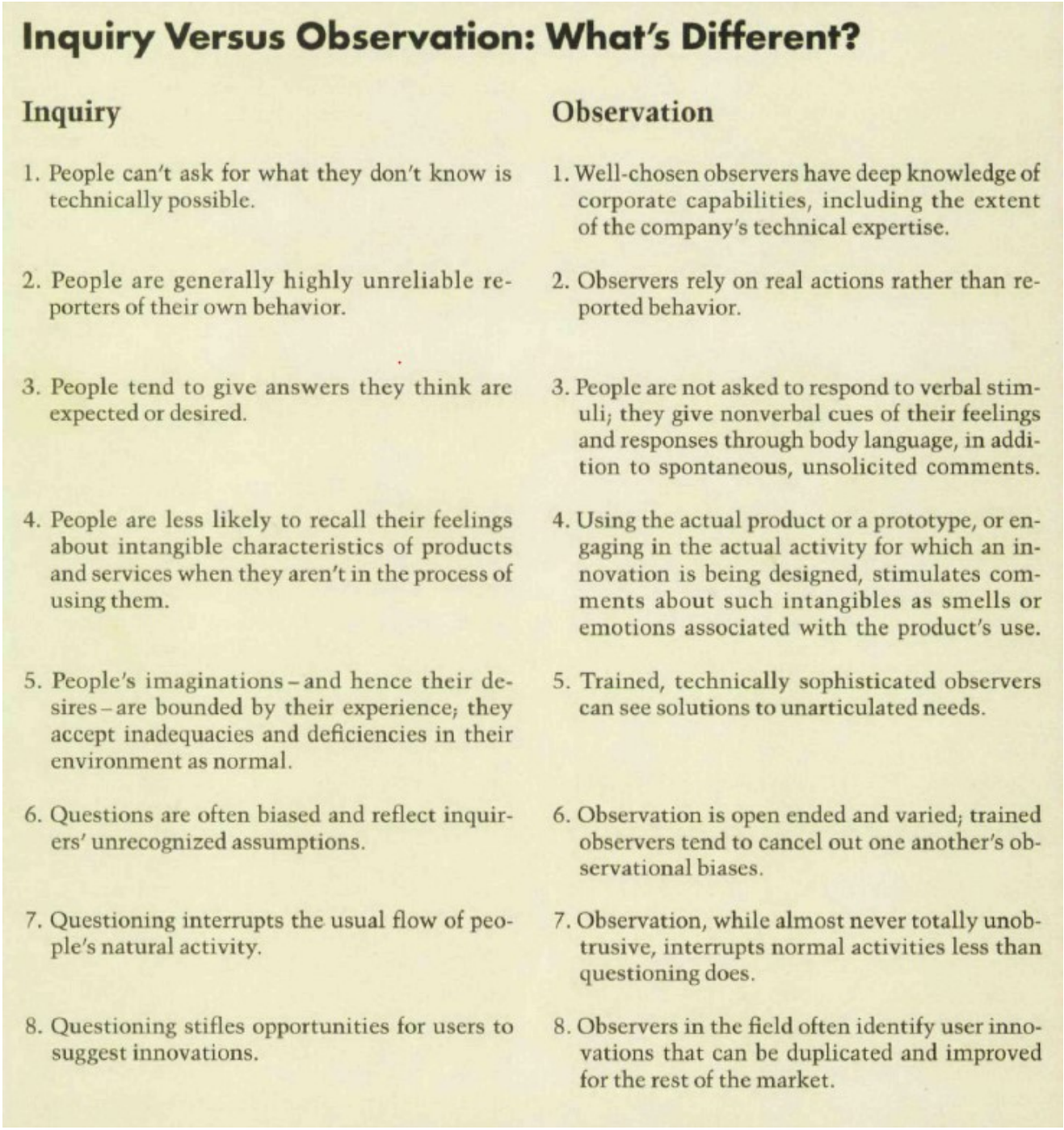
1. **Triggers of use**
   Sometimes the product is not used or chosen to be used for the anticipated reason. These unexpected or uncommon triggers for the use can lead to innovation or re-design of the product.
2. **Interactions with the user´s environment**

The product is observed in the user own environment and everything related to the product can be monitored. Even the most complex and subtle interactions and connections involved to the use can be seen.

3. **User customization**
   Finding user modifications can lead to a notice of shortcomings of a product. The user modifications can be as simple as personal identification to a product that is hard to distinct from other similar products.
4. **Unarticulated user needs**
   The observation of user using the product and encountering problems that they are unable to address or even recognize as a problem holds the greatest potential. Inventing solutions to those needs create clear benefits to the user.

The emphatic design responses well to the critique presented to for traditional market research. The comparison of the critique pointed to

inquiry based market research and how observation based techniques relate to the critique is presented in figure 15.



Inquiry Versus Observation: What's Different?

Inquiry	Observation
1. People can't ask for what they don't know is technically possible.	1. Well-chosen observers have deep knowledge of corporate capabilities, including the extent of the company's technical expertise.
2. People are generally highly unreliable reporters of their own behavior.	2. Observers rely on real actions rather than reported behavior.
3. People tend to give answers they think are expected or desired.	3. People are not asked to respond to verbal stimuli; they give nonverbal cues of their feelings and responses through body language, in addition to spontaneous, unsolicited comments.
4. People are less likely to recall their feelings about intangible characteristics of products and services when they aren't in the process of using them.	4. Using the actual product or a prototype, or engaging in the actual activity for which an innovation is being designed, stimulates comments about such intangibles as smells or emotions associated with the product's use.
5. People's imaginations – and hence their desires – are bounded by their experience; they accept inadequacies and deficiencies in their environment as normal.	5. Trained, technically sophisticated observers can see solutions to unarticulated needs.
6. Questions are often biased and reflect inquirers' unrecognized assumptions.	6. Observation is open ended and varied; trained observers tend to cancel out one another's observational biases.
7. Questioning interrupts the usual flow of people's natural activity.	7. Observation, while almost never totally unobtrusive, interrupts normal activities less than questioning does.
8. Questioning stifles opportunities for users to suggest innovations.	8. Observers in the field often identify user innovations that can be duplicated and improved for the rest of the market.

Figure 15. Difference of inquiry compared to observation (Leonard 1997)

The emphatic design techniques or ethnography are familiar to top design companies, but are not a common practice (Cooper, 2010). The emphatic design has similarities with anthropology and thus absent in most of the marketing science literature (Leonard, 1997). Implementing emphatic design requires more cooperation between organizations more closely

involved than ordinary market research. Emphatic design is something that researchers are traditionally not trained for, and require more collaborative skills than traditional product development. Even when emphatic design requires uncommon expertise, it is low-cost and low risk method to actually test and practice in order to identify customer needs (Leonard 1997).

There is not an established process for emphatic design or even clear boundaries how extensive the method is compared product design or R&D. In this paper, the method is seen as an important part of the customer orientated process of developing deep and rich understanding of the customer needs. A process by Postma, Lauche & Stappers (2012) has a good presentation of the regular phases and the designer, researcher and user roles and interactions during emphatic design process, presented in the figure 16.

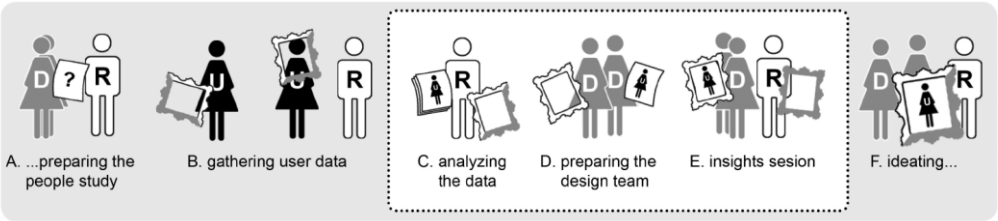


Figure 16. Emphatic design process and different interactions in the process (Postma & et al, 2012)

Leonard (1997) has identified a five-step process for the emphatic design with more detailed notions on the different steps:

1. **Observation**
   Decisions are made on who should be observed and who is going to be the observer. The observed individuals may be customers, noncustomers, group of individuals who perform a collective task. Different people extract different information from same situation. Even when people can be multi-skilled sending people with different expertise can lead to having more useful and very different data. Because the objective of observation is match unarticulated needs at least one member should understand the capabilities of the organizations development team and another have experience in behavioral observation. The people observed should be carrying their normal routines in their everyday life atmosphere. The observation can cause some stiffness to the observed person but is still valued over artificial settings.
2. **Capturing data**

The emphatic design is more observation based than inquiry most of the data is gathered through observation instead of responses to question born during the observation process. Most of the data is gathered though the observer and sometimes with the help of photography and video as tool to gather subtler cues. Photographs can also communicate information that might hard to describe verbally.

3. **Reflection and analysis**
   After the data gathering, the team members return to reflect on their observations and review visualized data with other colleagues. The group will focus on the data in order to identify all of the customer problems and needs.
4. **Brainstorming for solutions**
   In emphatic design, brainstorming is used to transform observations into more visual and presentable solutions. In order to achieve solutions five rules are presented: defer judgement, build on the ideas of others, hold one conversation at a time, stay focused on the topic and encourage wild ideas. The value is not only the ideas created at the time but also the ideas that can developed after the process.
5. **Developing prototypes of possible solutions**
   The prototypes are a critical part of the empathic design. Prototypes helps clarifying the new product or service to the team and represent the concept to individuals outside the development team. They can also be used to stimulate a reaction from customer and enlighten customer on the product or service benefits.

3.6.3 Lead users

The lead-user method is part of the voice of customer methods identified as effective for ideation (Cooper 2010). The lead user research is done in the early phase of the product development project for the purpose of identifying opportunities and developing concepts (Churchill, von Hippel & Sonnack, 2009). The term lead user was developed by Von Hippel and was first introduced in the 1986 article Lead Users: A Source of Novel Product Concepts. The main argument of Von Hippel (1986) is that the lead users have strong needs that are the needs of regular users of tomorrow. Thus, lead users are important source for identifying novel or latent needs that will become important in the future.

The lead user is defined by two main characteristics (Von Hippel, 1988):

- Lead users face needs that will be general in a marketplace, but they face them months or years before the bulk of that marketplace encounters them

- Lead users are positioned to benefit significantly by obtaining a solution to those needs

Lead users encounter needs for products or services that don´t yet exist in the marketplace. The lead users' placement in the product diffusion clarifies the lead user relation to other user presented in the figure 17. (Churchill et al., 2009)

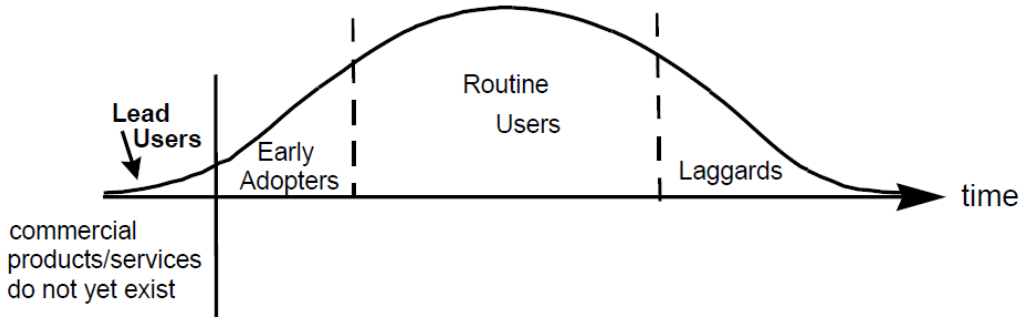


Figure 17. Lead users in the product diffusion diagram (Churchill, von Hippel & Sonnack, 2009)

In short, lead users are ahead of their time with their needs that don´t have existing solutions in the marketplace. Von Hippel (1988) also provides an example of a lead user as following "a manufacturing firm with a current strong need for a process innovation which many manufacturers will need in two years´ time" and thus the firm would be lead user of that process.

Important notification is that lead users are not always users in the company´s field of expertise and looking lead users in analog fields is highlighted (Von Hippel 1986; Churchill et al. 2009). According to Churchill et al., there are three different general types of lead users:

- Lead users in the target application and market
- Lead users of similar applications in advanced "analog" markets
- Lead users with respect to important attributes of problems faced by users in the target market

Lead users in the target market are experts related to the identified trend in the products market. Finding the lead users in company's target market is essential for identifying future needs. Lead users of "analog" markets are companies that are experts in similar need in more demanding market. The benefit of identifying lead user from analog fields is that existing solutions or advanced expertise related to need can be found. Von Hippel (1986) emphasizes that companies should seek lead users in places where the potential benefits for users are maximized. For example, automobile

industry has benefitted a lot from innovations developed originally to aviation industry, innovations like antilock braking systems (ABS) were first used in aircrafts before expanding to automobiles (von Hippel, 2005). Also, it is not always necessary to identify lead users that are knowledgeable about the entire product, process or service, but instead find lead users with respect to only a few of its attributes, sometimes even a single attribute (von Hippel 1986). This also enables one to find lead users in more unrelated markets to the product. Churchill et al. (2009) provide example of this as a case of an automobile fastener manufacturer that has a need to develop fasteners that are both more reliable and cheaper. The manufacturer could look into aerospace companies for reliability attribute since reliability is an essential attribute in the industry. Similarly, the manufacturer could look into how toy manufacturers keep their fastener manufacturing cost minimal.

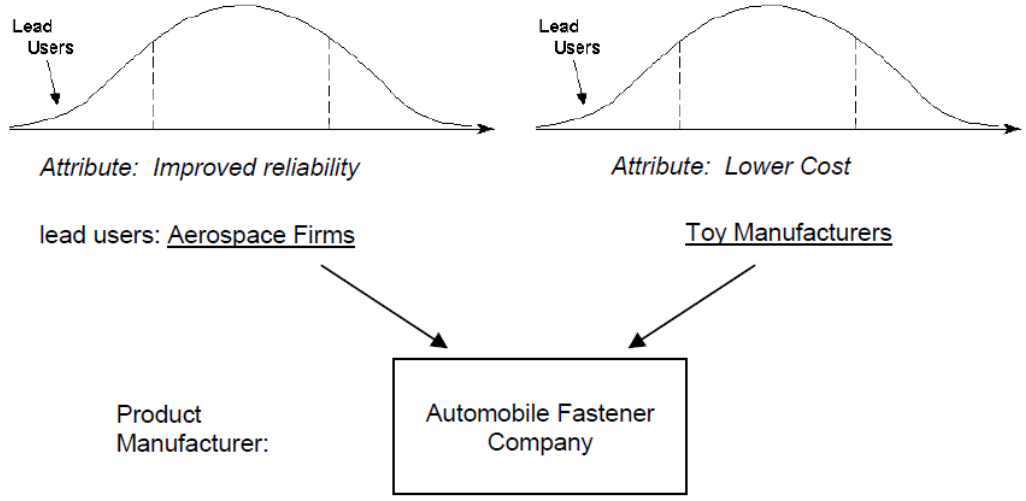


Figure 38. Automobile fastener company potential lead users for product attributes (Churchill et al. 2009)

Von Hippel (1986) created the lead-user method for new product development. The origin of the lead-user method is to tackle the problems related to traditional market research, especially for the problem that typical users are poor at evaluating unfamiliar or novel products. The lead-user method is a four-step process (1988):

1) Identify an important market or technical trend
2) Identify lead user groups
3) Generate concepts with lead users
4) Test and refine lead user concepts

Before the lead users can be identified, the development trends or product attributes interesting for development needs to be identified first. The goal

of the step is to select the need-related trend or trends that will be the focus of development work. When this is done, the lead users related to the trend can be identified. (Churchill et al. 2009)

Identifying lead users at leading edge of a trend is a process that starts by developing an understanding of the marketplace, its key players and trend related people in this field. Studying target markets, analog marketplaces or marketplaces where the trend or need is more severe is a starting point for finding leading edge companies related to the trend. Sometimes these companies are actively innovating to solve those problems and existing solution might appear. Other methods provided include surveying and seeking people with the leading-edge information or experience. In particular, the focus should be on the people with relevant new product ideas or experience developing a solution to the need (Churchill et al. 2009). (Von Hippel, 1986)

Concept generation begins with gathering data from lead users and their experiences related to the trend. The experience may include modifications to existing products or novel solutions the users have created in order to meet their needs. The gathered content is then used to create new product concepts. The generated concepts should answer the following question (Churchill et al. 2009):

1. What specific product attributes and features the concept will ideally deliver?
2. What benefits and value the product offers to the target customer?
3. What are the different key design features and ideas that eventually will form the product?

In addition, the concepts should be also analyzed with traditional market research in order to ensure the commercial possibilities of the product. (von Hippel, 1988)

Typically, the needs of lead users are not precisely the same as the major share of predicted market needs (von Hippel, 1986). Thus, the concepts developed need to be refined and tested to fit the regular user needs also. This is done in order to find wider commercial success for the product. In the end of this step, the development team goal is to have a fully developed new product concept with following elements (Churchill et al. 2009):

- Design specifications for the new product
- Research data confirming the commercial potential and the target market of the concept

- Idea or plan how the product will be developed and produced.

The lead-user method has been identified to have quite many problems related to the process. One of the main problems for the lead-user method presented is the problem related to identify important trends. The lead-user method provides very little detail how to identify the trends needed for finding lead-users. Another problem is that the lead-user method (von Hippel, 1988) don´t provide very concrete tools to identify lead users. Only suggestion to find actively innovation companies and surveying people with leading-edge information is given, how to find the leading-edge people is not stated. Intrachooto (2004) criticizes the lead-user method to be insufficient to the building industry, since the second condition of the lead user being someone positioned to benefit from a solution to the problem cannot be completely met. The main problem in building industry is that the benefactors are usually not the innovators creating little incentive for innovation. Intrachooto (2004) further argues that lead user method is not purposeful for products used by multiple people and require combined efforts. According to Intrachooto (2004), the lead user method also assumes:

- expert users will lead to innovations
- lead users already exist and only needed to be identified
- individual needs are the source of innovations
- products are single-purpose or task-specific

These assumptions may or may not be true depending on the product and may create problems when lead-user method is used. When the lead-user method might not be recommended for creating entire new products it still can be effective tool for developing new features and attributes to existing products.

4 Construction product industry

4.1 Characteristics of construction industry

Construction industry has been slow to develop compared to other major industries and there is a universal recognition that the construction industry needs to improve its performance (Fairclough 2002). There are also worries on lack of innovations overall and the concentration on incremental innovations. The lack of innovation affects the long-term competiveness of an industry and is evident in mature and price orientated building industry. The companies in construction industry has been also blamed for low investments in R&D and for poor performance of R&D. This is evident in Finnish construction industry where the R&D expenditure as a proportion to turnover is smaller compared to other technology driven industries. In Finland the average expenditure for R&D for the whole industry is 3.0 %, for the construction industry it is 0.8% and for the construction product industry it is typically between 1-2%. (VTT, 2003). The UK construction industry have similar numbers (Fairclough 2002) as Finland and there is no evidence to state the situation is different in any nation.

The construction industry is a clear distinct economic sector, but still there is not a clear consensus why its innovational behavior differs from other industries. According to Reichstein, Salter & Gann (2005) there are six main factors that separate the building sector from others:

- **Repeatability of projects**
  Construction is largely project-based activity with temporary collaboration between different companies who at the end of the project disband. Disband of the companies and the temporary nature of the collaboration makes transferring information and inventions from the project to another difficult or even impossible. Since the projects are not repeated and cooperation is not continuous, it decreases willingness for further development of the construction process and the products.
- **Immobility of the product**
  Construction work mainly happens on the construction site and the final product is in most cases immovable. Construction location changes from project to project and creating routines is harder compared to other economic sectors. This limitation has smallest effect on the construction product manufacturer that can still mass-produce it´s products.
- **Custom demand**

Construction industry customers have usually relatively different needs for the product and almost every product is custom made. Thus, the customer plays a significant role in deciding different design and production features. The customer is technologically conservative and don´t demand innovations (Nam & Tatum, 1992). The "ultraconservatism" of customer limits how much construction firms can influence their own future markets compared to other industries.

- **Local markets**
  Although, the construction markets are international much of the competition is local. The conservative nature of construction markets slows the diffusion of innovation. In addition, the technology and knowledge transfer is usually limited to local markets. Even when the innovations are proved successful in local markets, relatively similar local markets tends to shun unfamiliar innovations. Making the innovation international typically requires vast investments and knowledge about the new markets and possible restriction. Typically, there is also local standards and regulations that require extra work and complicate the replication of the innovation.
- **Separated design, production and maintenance**
  Customer often chooses the project members by offering tenders for different tasks in the construction project. The customer or representatives choose among the bidders for specific task and determine the configuration of the design and production organizations. The selected organizations then need to find a way for cooperation and working together.
- **Fragmented value chain**
  Constructing involves many different organizations and requires a lot of cooperation between the organizations. The construction process is complex and diverse and identifying the overall value of innovation for the process is difficult. The innovation also needs to work with the existing environment, fit the expertise of the involved organizations and create value for all the main organizations involved such as manufacturer, contractor, designers and most importantly the customer.

The construction product manufacturer is stated to be in best position to tackle the challenges of difficult innovation environment of the construction industry. They are in more stable and standard markets than contractors and

designers due to mostly mass-producing standard parts. Product manufacturers also are in better position to develop their products compared to construction companies and design offices who mainly operate with unique projects.

The construction product manufacturers have had divergent feedback from researchers. Some of the studies lay heavy critique over the performance of product manufacturers industry and state that the product manufacturing industry's unwillingness to be part of development of the construction industry. While other studies suggest that they actually have been involved in the development of construction industry and seen as the mainly the only contributor of otherwise underperforming industry. (Vesa, 2014)

The negative critique towards the manufacturing industry is most likely legitimate, but compared to the other actors in the construction industry, the product supplier is studied to be by wide margin the most innovative party in Dutch construction industry. The innovations ascended in the Dutch construction industry were studied between contractor, architect/consultant and contractor and in case where the innovation could not be attributed to a particular party miscellaneous. In this study the supplier was found to be the most innovative party, the results of the study are presented in figure 19. (Pries & Doree, 2005)

	All innovations	Process innovation	Product innovation
Contractor	10.9%	18.2%	3.4%
Supplier	64.6%	50.9%	78.4%
Architect/consultant	8.8%	10.7%	7.2%
Miscellaneous	15.7%	20.1%	11.1%
n=	422	214	208

Figure 4. The sources of innovation in Dutch construction industry (Pries & Doree 2005)

Interesting finding is also the major role of the supplier in the process innovations. It seems that the product manufacturer plays the main role in development of the construction industry as a whole.

4.2 Construction process

Since the construction industry is a comprehensive industry that include diverse variety of different type of construction there is also multiple types of construction processes. The main tasks in the construction process are the architectural and structural design and the construction work. Architect

and structural engineering companies do the design work and the contractor does the construction work and the management of the construction site. The main difference between different construction processes is at what stage the design offices and contractor partake the process.

From construction product industry's perspective, the variety and complexity of different construction processes creates a problem on identifying the party who has the most influence on deciding the used construction products. Since the contractor, consults and designer's role vary in different projects the decision making of construction products varies along the project.

In principle, the designer is responsible for the construction drawings and thus responsible for deciding what type of products are used in the construction. Still lots of the construction products are standardized and the contractor is free to decide the manufacturer as long as the products has same technical properties. In some cases, the contractor also alters the prepared design to gain advantage for the bidding competition. Thus, both the designer and contractor are highly involved in the selection of construction products.

4.2.1 Design-bid-build process

A traditional building process is called a design-bid-build process or in short DBB-process. The name "traditional" comes from the popularity of the process. In DBB-process, the architectural and technical design of the construction is decided first and afterwards the contractor is chosen via bidding competition.

The process starts with the builder selecting consultants for the project and with the help of consultants selecting the designer. The designers then prepare design and create the construction drawings that are presented to the contractor. The contractor then evaluates the documents and calculate an offer for the project. Usually the contractor with the lowest bid is chosen for the project. The process is presented in figure 20.

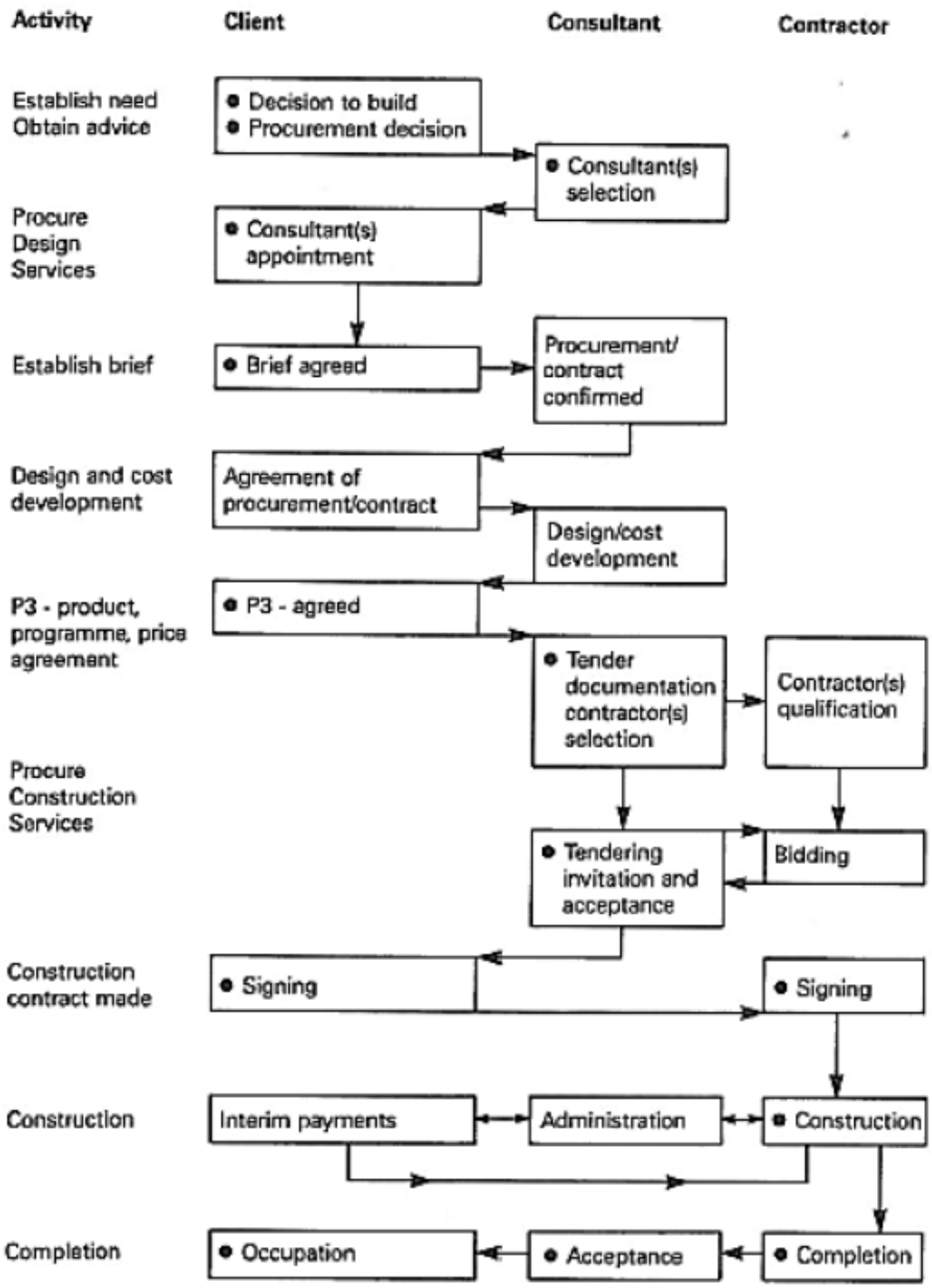


Figure 50. DBB construction process diagram (Turner, 1990)

The main character of the design-bid-build process is that the design and construction drawings are progressed far before the contractor even partakes the process. This leads to a situation where different parties are responsible for the design and construction. (Bolpagni, 2013)

4.2.2 Design-build process

The other common process is design- build (DB) where the contractor is selected first for the project. The contractor is then responsible for the entity and manage both the design and construction of the construction. The contractor is then in responsible for the whole project and depending on available resources does the design and construction work or is responsible for subcontracting the work. The process is presented in figure 21. (Bolpagni, 2013)

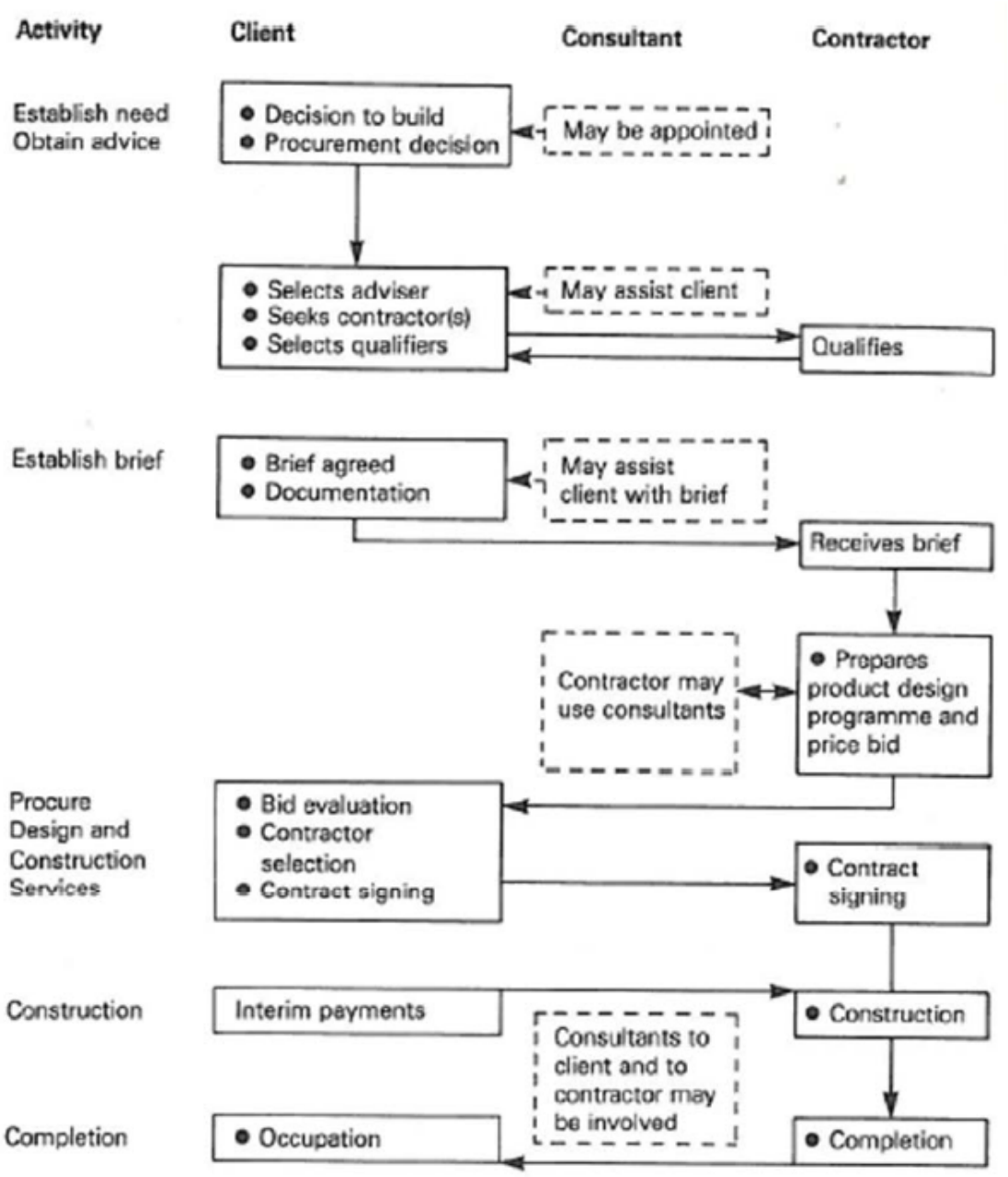


Figure 6. DB construction process diagram (Turner, 1990)

4.3 The customer of construction product industry

The current state of the construction product industry is alarming since there is not a uniform understanding of who or whom the customer even is. The situation is severe enough that Vesa (2014) states that in a way the customer is lost for the construction product industry. When there is lack of consensus who the customer is, it is also difficult for the industry to develop and create innovations based on customer knowledge.

One of the reason the customer is lost is due to different processes for construction where different parties could be seen as the customer. The construction product industry also has a complex value and innovation network that complicates the matter of finding who is the customer and onto whose needs are most important for the products success. The innovation network and value network for construction product industry is presented in figure 22.

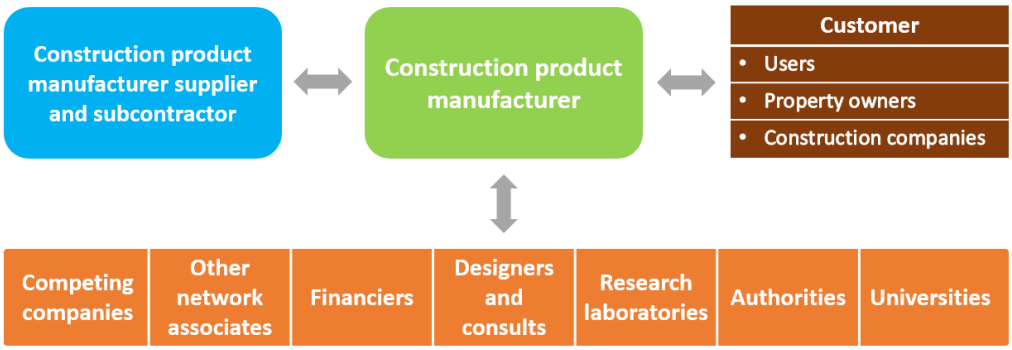


Figure 7. The fragmented value network of construction product manufacturer (Vesa 2014).

Vesa (2014) labels the building users, property owners and construction companies as customers for construction product manufacturer. The property owners and users are understood as customers since the initial investment and initiative for the building projects comes from them. Still the property owner or the user usually has little interest or knowledge about the construction product industry according to Nam & Tatum (1992) since the decision making is often outsourced and just assumed to fulfill the building regulations (Vesa, 2014). The property owners and users thus has only indirect link with construction product manufacturer since they are not involved with decision making towards their products.

The property owner and the user still has basic needs related to the whole construction, such as fast construction time, aesthetic, safe and economic price. These basic needs are important since they guide the decision making of the accredited party responsible related to decision making on

construction products. Even when they are hardly useful in practical level of product development.

Against common beliefs, Nam & Tatum (1992) found out that the demands of the property owner are usually responsive rather than initiative. The builder is usually positive for the use of innovations when the benefits are clear for the project. Nam & Tatum (1992) also present a case in which the customer approved a designer proposal of technologically more advanced solution for a bridge. The customer's satisfaction with the traditional bridge was shifted after faced with the new option. The new more advanced solution was chosen, overturning the conventional wisdom that the construction owner´s demands should always come first.

4.3.1 Users of the construction products

Deep understanding of the customer and the ability to empathize with the user or customer fuels the customer orientated product development. The ability to emphasize with the customer helps to identify latent needs and lead to development of new products. The feedback from the product users is important for the construction product industry; the users work daily with their products and are experts on their respective fields that allows them to have a unique point of view to the product. Because of the vast knowledge of their field and experience on the product, they are in position to have valuable insight on the product. Thus is vastly important for the construction product industry to identify the user or customer of their product.

When identifying the customer from product development point of view for the construction product industry it is more important to observe who actually are directly involved with the product rather than property owner and user that don´t have direct link to the product. In a way it is common sense that the people that use and work with the product and own experience have better knowledge and understanding of the product itself than those that are indirectly linked to the product.

This is backed up the studies (Little 2005, Von Hippel 1988, Cooper 2010) that highlight the role of product user's role in innovation. Since the property owner or the user in most of the cases have neither the knowledge nor experience on construction products it not reliable source of elaborate requirements and needs for the construction products industry to use for development.

Construction companies, design offices, suppliers and subcontractors are the customers for the construction product manufacturer from product development perspective, since they are the ones that actually are involved

with the construction products. The proposed customer chain of construction industry is presented in figure 23.

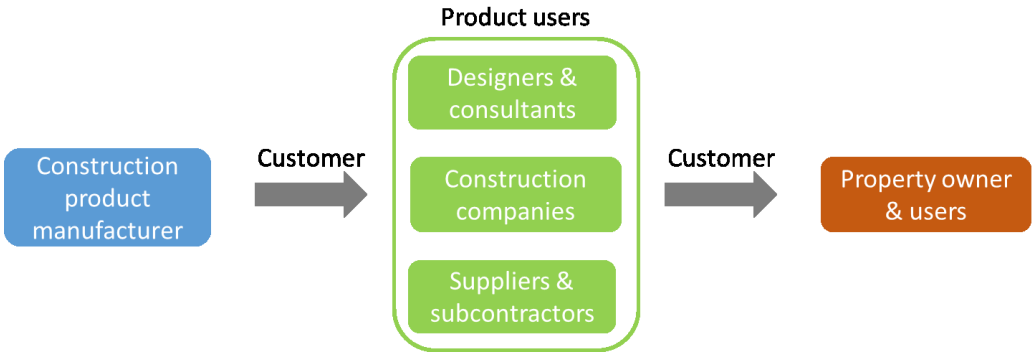


Figure 238. The customer relationships of construction industry

The construction product manufacturer still benefits from understanding the vaguer requirements of the property owner and the user, since they are the customer of their customer and whose demand they are trying to fulfill with their service or product. Still the focus of the product development for construction product manufacturer should be fulfilling the different needs of their own product users. The property owners and users will be partial benefactors of the construction product industry overall development since it will develop the construction industry as an entity.

The designers, construction companies and suppliers are also the parties that the principles of customer orientated methods could be applied and used effectively in product development. According to multiple studies, the proper focus on these user parties should enhance the output of product development and help the company to innovate.

4.3.2 Standard and nonstandard construction products

Construction industry has many standard products that have lots of competition and any product manufacturer's products are available for usage as long as they meet the local regulations. The products are standard and thus not that open for traditional product development that focus on improving the physical features of the product. In case of standard parts, the service aspect of the product prevails and service innovations are more important for the success of the construction manufacturing company. It is reasonable easy to understand that when all of the manufacturers sell the same product the product itself is not the central aspect for the success of the company.

Nonstandard parts are different from the standard parts as they are inheritably more complex as technical properties and capabilities of the

products are open for development along with the service development. Still they should benefit as much as standard products from service innovations.

5 CASE STUDY: CUSTOMER REQUIREMENT ANALYSIS FOR CONCRETE CONNECTIONS AND COMPOSITE STRUCTURES

Precast element has been widely used in the construction industry for a long time. The use of precast elements shortens on site the construction period and the need for manual labor in the construction site. Precast concrete systems enable improved speed of construction, high quality and less labor requirements. The main challenge related to precast elements are the connections between the different elements. Use of precast elements requires technical expertise on designing the connections enabling a monolith behavior that ensures the stability, strength and robustness of the building. (Mostert 2014)

The precast concrete elements are typically cast in an element factory, transported to the construction site and then erected. The precast elements are mainly used in order to create the frame of the building. The typical precast elements used are:

- Columns
- Beams
- Floor slabs
- Walls

Usually these precast elements have standard models available in the element manufacturers stock. Use of non-standard elements is also regular and depends on the construction project. Precast elements such as wall panels, staircases and room elements are also used but not as widely. The typical connections between the elements are:

- Foundation to column connection
- Column to column connection
- Column to beam connection
- Connection between floor slabs
- Beam to slab connection

The different connections are presented in the figure 24.

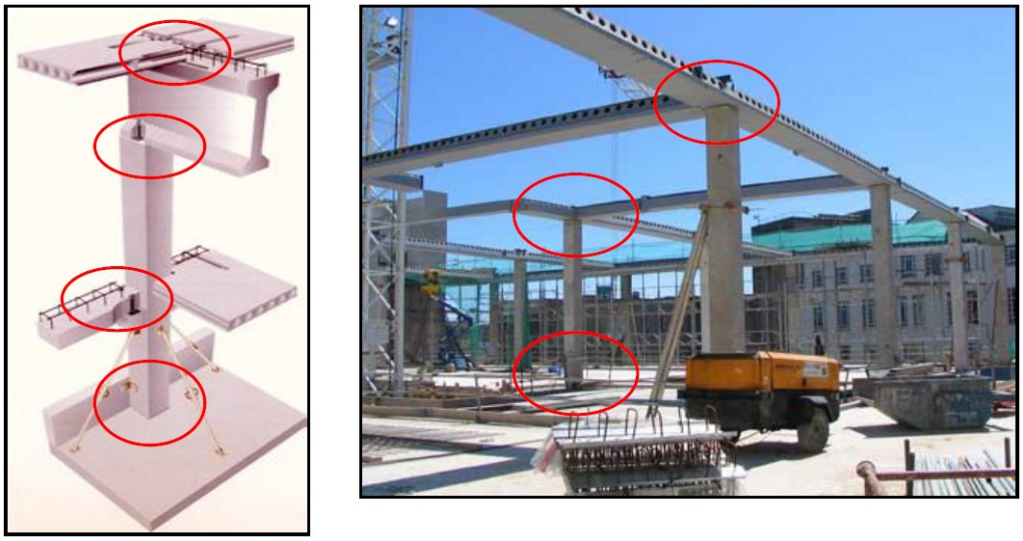


Figure 24. Most traditional element connections (Mostert 2014)

The concrete connection products are the most important part in the precast element construction, since they are directly linked to design and erection of the element construction, which are the most time expertise and labor intensive tasks in the process. (Mostert 2014)

5.1 Concrete connections and composite structures value network

When identifying the customer for construction product manufacturer it is important to observe what parties are directly involved with the construction product. In case of concrete connections and composite structures, the directly related parties are structural engineering company, contractor and element factory. The parties related to the product manufacturer creates the value network of the product that is presented in figure 25.

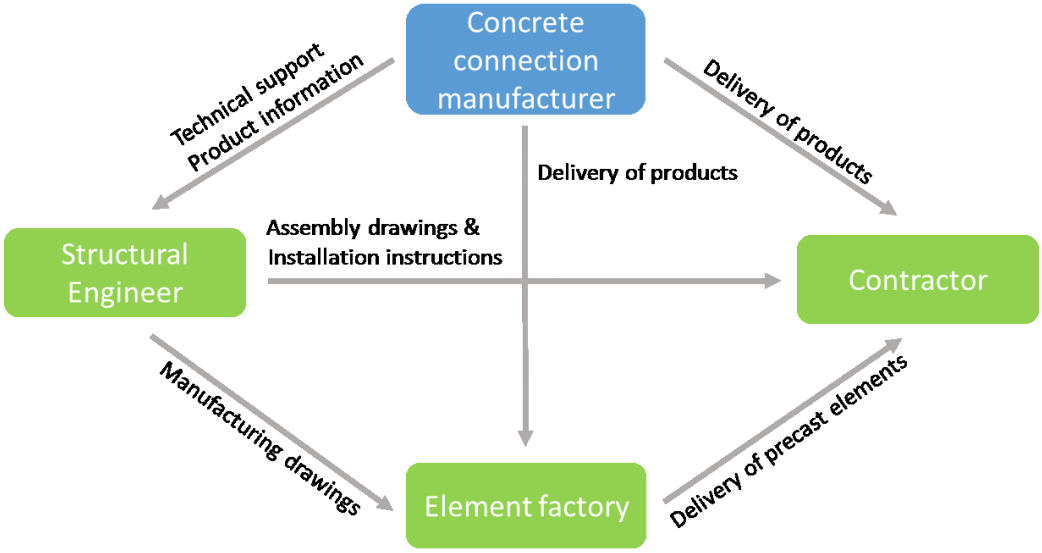


Figure 25. Value network of concrete connection manufacturer

Many studies have highlighted the role of the customer in R&D and the importance of deep understanding of their needs. The parties in the value network represents the customer for concrete connection and composite structures from R&D perspective. Thus, the R&D should focus their development work to meet the needs of these parties. The target of this case study is to find the needs of Structural engineering office, element factory and contractor that are the customer of the concrete connection manufacturer.

Owners and users of the construction aren´t in the value network for construction product manufacturer since they are not actively involved with the construction product. Owners and users are typically unknown or indifferent what construction products are used and have lack of interest in construction products used. This leads to a situation where the users and owners are unable to form specific needs for different construction products.

5.2 Contractor´s role in the value network

The main role of the contractor is the construction work and control of the construction site. The contractor is responsible of finished construction quality and in long term liable for construction defects. Generally, the contractor creates the schedule for the construction project and is responsible for keeping in the schedule. Staying in schedule is important for the contractor since it often works on piecework pay and the prolonged project holds the worker resources from moving to new projects. The

contractor usually also needs to compensate the delay to the property owner thus increasing the importance on staying in schedule.

The contractor's main competence is the ability to evaluate the offered construction project demand for construction work how much time it will take time to complete the project. When the contractor has experience on variety of different products, design and the how they affect their tender, they can change some of the troubling designs to make it more suitable for them. This will allow the contractor to drop down their tender and gain competitive edge. When the contractor is able precisely evaluate different aspects of the construction project will have the ability to find the right projects and the ability to win the price competition.

The contractor is also responsible for on site design modifications and usually the first one to notice impractical or even impossible details. Even when the designer has done the mistake, the contractor still needs to reschedule the project or do makeshift solution. Makeshift solutions are typical done to keep in schedule and to ensure the construction workers and subordinates can keep working. Sometimes the make shift solution may require modification of the element and taking of material in order to fit for tolerances or make room for building services engineering that can increase the risk of failure.

Sometimes the design consists of products that are not preordered which may cause an urgent demand for quick delivery of products to construction site. New structural solutions and new construction products also increase the risk for mistakes and delays during the construction and thus contractors have a tendency to favor known and established solutions familiar to them. The long-lasting responsibility for construction quality makes the contractor to favor conservative designs that are time tested. Contractors favor familiar products and designs in order to avoid risk of setbacks, but also to increase the routine of the workers. When the workforce have previously worked with the product, the contractor will benefit from the decrease of construction time and improved quality.

From new product development perspective, it is a problematic situation that old products are favored over new ones. Even when the contractors are open to change and are interested in new products, by the nature of their business they also need to be vary of new products. This leads to a situation where the new products needs to be better than previous generation products and have enough potential and benefits to create interest. When the contractor sees potential in new products, they are first tested in pilot

projects, where the contractor collects experience on the product. The contractor main interest in the new products is to have experience and knowledge over new products since will keep the contractor competent in the future.

5.2.1 Contractor have a good position to evaluate the quality of the construction product

Contractor possess a good viewpoint of understanding of the overall quality of a construction product. They are responsible for the virtual use of the product and thus have in practice knowledge the product. Contractor then has knowledge of possible benefits or disadvantages of those products familiar to them. This allows the contractor to properly estimate the products overall value for construction workflow and quality. Still there is little incentive for contractors to distribute the knowledge of best products and construction solutions to designers or the product manufacturer. Usually the contractor's focus is on operating current projects and negotiating new projects and there is no time reserved for consulting designers or product manufacturers.

The contractor does not directly benefit from the development of the construction products since the contractor is still in price competition against other contractor and when the products are labor friendly it just decreases the tender and does not benefit the contractor. Still the contractor can have clear-cut benefit when the new products emerge that can be used to improve the proposed design of the project. The knowledge and experience of new products thus helps the contractor to make competitive bids and the information of new product quality is valuable. Thus, the information knowledge of the quality of products is important to them but not the development of the products as much. Often it means the contractor is not interested in the new product development and keep the knowledge of different product in house to prevent their preferences from leaking to competitors. Thus, the knowledge transfer between the contractor and supplier is not evident.

The knowledge transfer within the construction company has also problems because of subcontracting. Subcontracting some of the construction work is common procedure for construction companies, but the subcontractor has limited interest on reporting problems or difficulties faced single products or designs. Similar problem is also evident with the contractors own construction workers, whose job is in basic construction work not in evaluating the quality of the products used.

The construction site manager is responsible for keeping the schedule and supervising the site and reporting to the management on the progress and event on the site. The site manager is also in direct relations with workers and is contacted in case of problems. Since this unique role of being close to management and workers the construction site manager in best position to notice difficulties with different connections or notice the high quality of certain products that helps the projects to succeed. This makes the site manager a crossing point of knowledge inside the Construction Company and interesting person for the product developers.

The feedback from the user of product from the construction worker to the construction product manufacturer is traditionally a long chain where the information moves from people to people. In most cases, the user feedback is either filtered too much or never heard. The situation is completely different for consumer goods where the customer is directly linked to the product manufacturer and possible complaints are often coming straight to the manufacturer unfiltered. The different feedback loops are presented in figure 26.

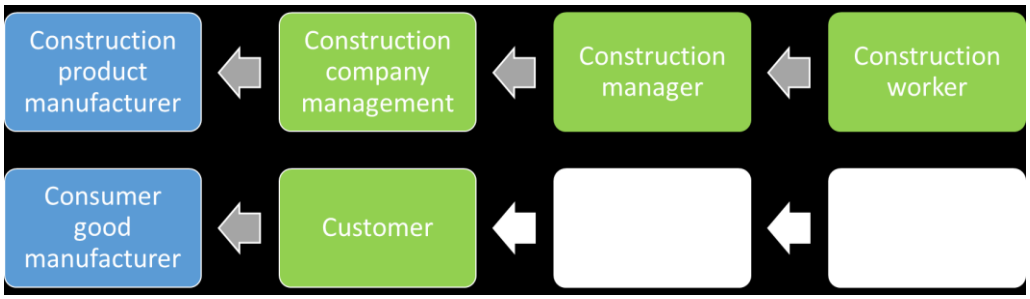


Figure26. Feedback chain of construction product and consumer good

5.2.2 Contractor´s relation with the concrete connection supplier

Since the contractor's main role in the construction process is to organize and coordinate the construction it will need to have good connections with the products and element suppliers. In order to create the schedule, the contractor needs to know how fast and how reliable the supplier can transport the needed products and elements onto the construction site. The supplier reliability to transport the products in time is in high value since it will decrease the risk of delay and avoid the construction site to stand still. The reputation of being in time being reliable is important for the supplier, since the delays are so expensive for the contractor.

The common way to handle the business between the contractor and supplier is to negotiate an annual contract that dictate the delivery time of

the product with a standard cost. This will then ensure the contractor can manage the flow of the products and eliminates the need to negotiate the price for every project individually.

In case of standard connection parts, the contractor usually values the price, short delivery times and previous good experiences dealing with the supplier. Usually the contractor can use any supplier's standard parts it is difficult for the supplier to create deviating products. The standard connection markets are thus mature and the competition is mostly done for the price, delivery times and reliability of the delivery.

Since the contractor is responsible for the actual installation work and practical use of the connection products it has the best point of view to estimate the products value related to amount of labor required and the time required for installation which are requirements for all connection products. Still the contractor might not be able to articulate what properties are the most desired related to concrete connections.

The frame of the construction is one bottleneck of the construction project. It was also stated that in construction projects were the frame was completed in time were mostly successful and on time. The most demanding task in erection of the frame is to connect the different elements together to in order to create the frame. Good connection solutions enabled by different connection products ensure the fluent progress of frame and prevents setbacks or in worst case ad hoc on site compromises.

5.3 Structural engineering company´s role in the value network

The structural engineering company´s construction process usually consists of two phases: offer phase and the design phase. The offer phase is where the companies create preliminary design for the project and compete for the projects structural designer's role. Typically, the focus is for projects that the company has special expertise and thus can create extra value with their design capabilities. The design phase consists of creating detailed design for the structure and sorting out what products and services are available for the project. Typically, the design phase and the design process has strict guidelines and same technical solutions and products are re-used in order to ensure design quality and time.

The offer phase for structural design is used in projects where the structural designer is not selected beforehand and the structural design work is set for competitive bidding. After the proposed designs are evaluated, the

structural designer for the project is selected. The structural engineering company typically enters only competitions where it has special knowledge and expertise on the particular project and reasonable probability on winning the design job. The negative effect on losing is that all the work done is wasted, as losing bids do not return any income.

After the main structural designer for the project is chosen, the structural engineering company can create the detailed design for the construction. The design work with the products is done with computer-aided engineering. The construction and the details are built into a structural model and created to handle the stress that construction is facing. The structural engineer needs also to be aware on different manufacturer's products and their compatibility. Typically, the designs are done with the help of design libraries that consist of solutions for different structural designs that meet the local standards and demands. The designs are also checked and verified by construction authorities that they meet the regulations and safety standards.

The structural engineering company also provides manufacturing drawings for the element manufacturer. The element designs are often done in cooperation with the element manufacturer in order to ensure the given elements fit the manufacturing line and its limits.

The structural engineering company needs a lot of cooperation and information in order to create proper designs and needs to consider many variables from different parties in the construction process:

Construction product manufacturer

- Technical details of the products and possible restrictions
- Compatibility with different products from different companies
- Manufacturing timetables

Element Factory

- Possible restrictions for the elements and can they be made
- Cost effectiveness and suitability for the assembly line
- Transportation restrictions
- Production timelines

Architect and Owner

- Design preferences and limitations

Contractor

- The products used are construction site friendly

As it is evident, besides the expertise in structural design the structural engineering company needs to be able to gather and manage lots of information in order to create proper designs for the project. Since, there is relatively large number of variables that affect the design the design process is created to be as uniform and automated as possible for every project.

5.3.1 The structural engineer's relation with the construction product

The structural engineer's relation with construction product is manifold. The designer is the person that is responsible for making the decision what products are used in different parts of the construction. One could argue that the since the designer is the one who chooses the product it is the person that construction product companies should focus on. In case of non-standard parts, it is true that the designer has the main role on deciding what products are used in the construction. Whereas with standard parts the element manufacturer or the contractor can use any manufacturer products as long as the products used have the same technical properties. This leads to ambivalent situation where at the same time the structural engineer is important and not that important for the product manufacturer subject to products interchangeability.

Structural engineering companies have also an interesting relation with new construction products. New products are seldom used in standard projects where designers mainly use products and solutions from design libraries or products they are accustomed to. Still, structural engineering companies are interested in new products in order to maintain long-term competiveness. The structural engineering company is thus important for product manufacturers that are launching new products.

5.4 Element manufacturer´s role in the value network

Element manufacturer in general has a simple role in the constructing process, manufacture elements and supply them to the construction site. The elements are widely used in construction eliminating to create the construction elements in construction site conditions. The element factory provides an environment where elements can be manufactured more efficiently and with improved and uniform quality.

The element manufacturing industry is diverse as the factories and companies vary in size, manufacturing capabilities and capacities. Typically, the production line of the factory defines the size and weight of elements

that the factory can produce. The smaller manufacturers often rely more on manual labor whereas in the larger facilities and factories the work is more automatized.

The element factories compete with each other for the manufacturing jobs. The bigger companies may have design consultation for the structural designers on creating the elements and component suitable for the factory in order create competitive advantage. Similar to contractor the element manufacturers also have annual contracts with construction product manufacturers and traditionally exchanges the products that don´t require modification to its preferred supplier's products.

The element manufacturer may have a design unit and provide design support for the structural engineering but traditionally the role of the element factory focus on acquiring new manufacturing projects and keeping the manufacturing lines running. Cooperation with the element manufacturer and the structural designer often focus on finding the right products for the elements that are suitable for the production line of the manufacturer. The construction products are still not exchanged if it requires redesigning of the element.

Delays are as unwanted and costly for the element manufacturer as they are for any other player in the construction process. It is not good for the business if the element factory is on a stoppage or the arrival of the elements to the construction site is delayed. The element designs are also traditionally vulnerable for re-design and minor changes. Thus, it´s understandable that the element manufacturer values fast delivery times and reliability that allow more flexibility to the element manufacturer and helps to prevent different type of working delays. In addition, there are cases where the need for the elements comes suddenly and the elements are needed as soon as possible in the construction site, where element manufacturer will also benefit from the fast delivery times.

5.4.1 Element manufacturer´s relation with construction product

In a way, the element manufacturer is indifferent into the overall value of the product on the construction process. The designing of the elements it´s not the responsibility and expertise of the element manufacturer. The element manufacturer role considered to the type of products that are used is rather small and in relation to the design consultation to the designer on the factory needs. The parts that are replaceable with similar products are exchanged according to the needs of the element manufacturer.

In case of standard connection parts that are used in the elements, the element manufacturer has the main role deciding what product manufacturer products are used. Understanding what the procurement policy is and what factors are considered during the procurement process is important knowledge for the construction product manufacturer.

The element manufacturer can benefit a lot from short delivery times and reliability of delivery are highlighted as very important demands towards the element manufacturer. The products suitability for the element factory is important but much harder to quantify and articulate what are the most important factors. The physical property demands are not uniform since production lines are not standard or uniform and different products work better in different factories. The important parts is to identify what causes the most unnecessary work and inconvenience to the factory and if the products can be modified to suit the factories more.

6 Customer requirements for concrete connections in different parts of the value network

6.1 Contractor´s needs

The contractor’s needs consist mainly of product properties that are related to working with the connection and connectivity of the construction product. Even though, there is many physical properties related to the construction product the service aspect is as important to the contractor. The service areas main development subjects for construction product manufacturer are delivery times and delivery reliability. The properties related to constructability can have variety of solutions ranging from innovative manuals to completely new attachment mechanics whereas service development is dependent on the product manufacturers processes and which require different type of development. The contractor needs are presented in the table 2.

Table 2. Contractor's needs

1st Level	2nd Level	3rd Level
Physical product	Technical properties	- Allows connectivity from multiple directions - Adjustability - Sufficient tolerances - Needs small amount of labor - Reduce number of connections - Provide secure lifting - Fulfil standards - Constant quality
	Modularity	- Parts and elements standardized - Products are replaceable - Functions with wide range of products
	Installation	- Instant load support - Easy connectivity - Installation unambiguous - Parts easy to recognize - No need for additional supports - Don´t create additional waste - No need for inspection - Mechanical connectivity - No need for expert workforce
Service	Supply	- Short delivery times - Products provided on time
	Customer support	- Customer service availability - Information of product availability
Symbolic	Brand	- Product is familiar to workers - The company is reliable

6.1.1 Contractor´s needs related to faster construction

The construction time is essential part of success for contractor. Projects that stall and don´t meet the set schedule may end up non-profit or even losing profit. The successful construction of the frame is stated to be key part of the overall success of the construction project. The concrete connections and composite structures play the main role in the frame construction and smart solution and products ensure minimal setbacks for the progression of the project.

The main cause of setbacks in the construction time are poor original designs and the need for re-design or applied solutions by the contractor. Another time related are problems are a need of expert workforce and labor intensive design solutions. The physical properties related to desired product attributes were mostly related to modularity and bigger elements. The bigger elements require less connections and labor in the construction site.

The need for design changes is regular nuisance in the construction industry. It is difficult to notice possible poor design before they cause immediate problems in the construction site. In worst case, the whole construction site mostly ceased and the labor force is unable to continue with their designed task. This is particularly expensive considering the error is creating new work like re-design or inventing applied solution and at the same time prolonging the construction completion and delaying the benefits for the owner. The concrete connections need to be also easy for designer to design with, in order to prevent design mistakes and redesign work.

The modularity is key attribute of the concrete connection product. There are always major problems related to schedule when planned element connection fails to be done properly. It doesn´t matter if the error is cause of design, installation or product quality, the possible redesign and ad-hoc solution requires time and may cease the construction site. The desired properties related to modularity where mechanical installations and immediate rigid properties nullifying the need for additional temporary support constructions. Another important factor related to modularity is traditionally large tolerances of the construction. Since construction accuracy is hard to maintain an adjustable connection can create value and prevent new orders of products that don´t fit the frame. The adjustment also enables to tackle the problems related to ad hoc design and especially more imprecise construction projects such as renewal work where exact tolerances cannot be met anyway.

Welded connections are also possible setback since they require specialized workforce and in case of sick leaves or lack of specialist available can slowdown the construction site. Welds also require quality inspections that are considered as slow and tedious extra work compared to other connections that don´t require inspections.

The number of connections and elements in a construction project has a direct effect on the workload. Connection solutions that enable the use of

bigger elements or reduce the number of connections have a major potential to make the constructing faster.

6.1.2 Contractor´s needs related to ease of construction

The practicality and ease of construction is important factor for the contractor. The practical products and design solutions helps to avoid the mistakes and uncertainties during the construction phase. Solutions that makes the construction easier usually also improve both the construction speed and safety.

The factor that stands out for the ease of construction for the contractor is the modularity and connectivity of the elements. The extensive use of standard parts and elements increases the modularity and the repeated use similar elements and construction products makes the construction work easier. The most difficult part of the construction is attachment of the elements especially for the elements that are not aligned but rather come from different directions with varying angles. The ability to connect these difficult elements with instant load carrying connections is thus highly valued.

Generally, elements that require temporary supports during construction are considered difficult and undesired. The making of the temporary supports requires precise work for safety reason and needs to be created on site. The temporary connections are not considered also not as reliable as connections immediately bear weight after the attachment.

Thus, adjustable mechanical connections are valued for their ability to have instantly bear weight and the improved connectivity since construction work is typically not millimeter accurate or fulfilling strict tolerances is exceedingly difficult. Ability to handle large tolerances is even more important in renovation sites where the construction inaccuracies are even greater and more unpredictable.

The contractor has also interesting relation with welded connections. In many cases they are considered unwanted but in some case are an only option and thus widely used. The main difficulties that contractor phases with the welded connections are the weight bearing welded connections that require the check of the quality of the weld. The quality check is important to prevent accidents and construction failures. The quality of the weld is extremely difficult to verify and considered as tedious and unpleasant work that the contractor would avoid, unless there is no other options. The welds also require specialized workmanship that is not always available when needed.

Manufacturing elements in construction site is considered time consuming and difficult and risk for failure is increased. The casting of the elements also requires making of molds for the element and the disposal of elements from the molds and disposal of the molds after they are not needed create extra work. The casting of the element require precise assembly of the elements parts before the casting and control of the quality may cause problems. The element factory has many benefits compared to the construction site: Uniform workspace and working conditions, specialized workforce, equipment for mass production etc. It is understandable that the quality of the elements is considered better when created in element factory instead of in the construction site.

The element factory can also manufacture bigger elements. The bigger elements can reduce the number of elements used for the construction and simultaneously the number of connections. It can be argued that bigger elements are in general more difficult to connect since they are heavier and more difficult to handle. Regardless it was seen as a possible solution to ease the construction work to use bigger elements.

6.1.3 Contractor´s needs related to safety of construction

Construction work is mostly done manually and human errors happen from time to time. Unfortunately, for contractor instead of just economic loss there is also a possibility for human casualties. There is no price for human life or injuries and safety is one of the top priorities of construction companies. Contractor thus has always interest on products that improve safety of construction and workers.

The ease of construction is linked with safety. Easy connectivity cause fewer installation mistakes and helps preventing dangerous situations. In addition, the need for additional supports during construction for connections is seen at all times a risk. Overall, it seems that the difficulty and amount of work needed for the connection is in direct link with the safety.

Most of the errors done in the construction site is related to the incorrectly prepared connections. The risk for incorrect installation is increased with new and unfamiliar products when additional installation information is needed. The installation information flow to the construction work can sometimes be lacking or the manual is just misinterpret causing the failure. The possibility for misunderstanding is typically increased in multilingual construction sites where there the workforce is not able to have manual in their native language. There is thus real need for proper and universal installation manuals for all of the new products.

Safety hazards are reported to occur in situations where different products are difficult to distinguish by the appearance. When a product is mixed with a product that have different or inferior mechanical properties it can cause a mechanical failure or prevent the elements from connecting at all. For example, different standard threaded connections could be fitted together but will not have the desired mechanical properties.

6.2 Structural designer´s needs

Structural designer´s needs are more comprehensive than element manufacturers or contractors, since the structural design decision affects all of the construction phases. The element manufacturer and contractor can focus only on their expertise and still be successful but the designer needs be able to see the bigger picture. The designer makes decision based on the overall value of the product and avoids products are troublesome for the element manufacturer or the contractor. Even when the element manufacturers and contractor´s needs are important to the structural designers, the structural designer´s need deployment chart covers the needs of contractor and element manufacture superficially, as they are reviewed more comprehensive in other chapters.

Table 3. Structural designer's needs

1st Level	2nd Level	3rd Level
Physical product	Modelling	- Good compatibility with other products - Availability of design information - Sustain small errors - Fulfils local standards
	Product	- Contractor friendly - Element manufacturer friendly
Service	Supply	- Information on product availability - Production timetables - Products provided on time
	Customer service	- Design information availability - Design tools provided - Design help provided - New product consultation
Symbolic	Previous cooperation	- Positive history with the product - Lack of previous re-design work - Willingness for cooperation
	Brand	- The company has good reputation

6.2.1 Structural designer´s needs related to faster design

The amount of design time used for structural design is typically not that related to the products that are used in the construction and not the main concern of structural designer. The time that can be saved in the design phase is often minor compared to what proper designs and products can save on time in the element manufacturing and erection phase. Typically, the designer is concerned on the overall effect on construction time rather than the pace of the design.

The designer still values products and services that ensure pleasant design pace. The designer also creates the timetable for the project, which makes the product availability information and manufacturing schedules important need for the designer. Typically, the designer chooses products that can be supplied to the construction site or to the element factory so that the construction phase can start without unnecessary delays. The start of the design can also slow down if the supply information of products is unavailable.

Manufacturers design supports is important need when product compatibility or other design uncertainties arise that require specific consultation. The structural designer wants the product availability information as well the design consultation as fast as possible so that the design don´t have to pause or stop for too long.

Other important aspect for faster construction time is that re-design work is minimized. Re-design work is tedious and difficulty and not as straightforward as creating new structural design. Products that have too small capacity for structural modifications or any kind of error are avoided. The problem may arise already in the design phase or the product have caused errors in the construction site and thus avoided.

6.2.2 Structural designer´s needs related to ease of design

The major requirement for the product ease of design is that the product can be modelled effectively. Typically, it means that the product have either separate software or an add-on to existing software that can be used for the design work. If the software or add-on is easy to use and have desired properties, the need for design support is also decreased.

Comprehensive introduction to new products and software is also an important need of the structural engineer. The introduction will give the designer valuable insight on new products and it capabilities. In addition, the

designer is not left alone to figure out how to use the product or software effectively. The help from more advanced user in the learning phase of new software can´t be emphasized too much as it will make the learning for the designer much easier and faster.

The structural designer needs to know the products used thoroughly and thus wants the information related to the product as easy as possible. In practice, this means that the designer wants information on product specifications, compatibilities and availability at any given time.

6.2.3 Structural designer´s needs related to safety of construction

The design safety issues are important for the designer and sound products and design solutions are re-used. The structural design has variety of different standards and design codes that are created to ensure the safety of the design. The standards have safety factor included in the design and structural designers typically chooses the products have high utilization rate. Still, designer needs to know the product throughout and if there is doubt about the safety of the product, it will not be used.

Another safety factor is that the products have history without major safety issues. New products need to have clear benefit for the designer to be chosen over proven product.

6.3 Element manufacturer´s needs

The needs of element manufacturer regarding concrete connection are listed in table 4. The most important needs are delivery times and reliability of the delivery as they provide needed flexibility for the element manufacturer and helps keeping the factory running. Another characteristic of construction industry is that previous cooperation is valued, that holds true on the element manufacturer. The physical properties are mostly related how they fit the manufacturer’s production line and how easy they are to assembly.

Table 4. Element manufacturer´s needs

1st Level	2nd Level	3rd Level
Physical product	Element manufacturing	- Don´t require modifications to manufacturing line - easy to attach into element´s mold - Similar products easy to distinguish - Reinforcements easy to assembly - Assembly drawings easy to follow - No need for additional molds - Constant quality
Service	Supply	- Short delivery times - Deliveries arrive on time
Symbolic	Previous cooperation	- Product is familiar to workers - The company is reliable

6.3.1 Element manufacturer´s needs related to faster manufacturing

The element manufacturer´s for faster production can be divided to different type of needs. The delivery time and deliveries arrival on time help the element manufacturer ensure that the manufacturing keeps running without pauses and help starting new projects faster. The consistency of delivery is important since the element manufacturer plans the production timetables according to product flow and delays are costly. The fast delivery times helps to reduce storage size and helps to tackle urgent product needs.

Physical properties are minor factor in the element manufacturer's production speed. Mold manufacturing, drying of concrete and transportation are time-consuming tasks compared to connection product related tasks. The time saving is mostly achieved by having easy to use products that reduce the amount manufacturing errors.

6.3.2 Element manufacturer´s needs related to ease of element manufacturing

Most challenging task in the element manufacturing process is to manage the workers and the workflow in the factory. When the products arrive on time, the daily managing of the factory and creating production plans becomes easier. The daily workload is easy to share as predicted and there is no need for sudden changes in production timelines. When products arrive too late it may cause the element factory to cease and the workers without proper work for the day. After the cease, the production plans may require

additional modifications to ensure the successful supply of the elements onto the construction site on time.

Delivery times on the other hand give flexibility to the element manufacturer when they have urgent demand for new products. Short delivery time of products allows the manufacturer to have smaller storage sizes and helps the element manufacturer when the product need becomes suddenly and unexpected. In situation where the construction site needs the element as fast as possible and fast availability of the element is main demand it is important for the element manufacturer to be able to have the needed products as fast as possible.

The element manufacturer prepares the molds and assembles the parts to their position before casting the element. Most vital requirement on the physical properties of the product is modifications to the product line itself is not required. Products that allow uniform surfaces on the mold and don´t require creation of external mold are easier for the element manufacturer, such as hidden corbels. Hidden corbels allows the mold to have smooth surfaces and re-usable parts are considered easy and useful products.

Easy installation and fixation onto the mold is appreciated, if the product requires additional reinforcement it is important that the whole unit is easy install. When the installation is done manually the importance of clear assembly drawings and recognition of parts becomes important, as installation errors are unwanted. When products resemble each other, it is important to have clear identification system that workers can easily to use and learn for the differentiation of products.

6.3.3 Element manufacturer´s needs related to safety of element manufacturing

Safety is important for the element manufacturer. Still most of the safety risks are not related to the construction products used in the elements. Construction products can create risky situation when elements are moved and transported and the element falls. Good connectivity is thus important to element factory and the main purpose of lifting products. Lifting products can cause safety risk when products are mixed together and weaker part is installed instead of design part or the lifting parts are used improperly.

Discussion

The main goals of this study was to identify the customer of the construction product and capture the needs of the identified customer. Previous studies stated that the customer is lost for construction industry and there was not a clear consensus who the customer even is. Studies focused on the performance of product development agree that effectively meeting the customer needs is vital for the success of product development. Studies that focus in general product development theory suggested that the customer is who is in touch with the product and the product creates value to them. Principle of value network was presented and proved effective concept. Value network was created for the construction product and it enabled to identify the customer. The value network was identified in cooperation with a construction product manufacturer and researching the typical lifecycle of a construction product.

The limitations of this study is that it only focus on construction product industry in Finland. Findings may be different in different countries where construction industry is shaped differently and have different weather conditions and culture. In addition, all of the interviewees were working in Finland. The data was gathered using semi-structured interviewing method because the aim was to let the interviewees have their voice heard and explain in their own language what their needs for construction products was. All of the interviewees were experts in their fields and had a possibility to influence on the decisions concerning construction products or were working with them. This was done to gather data from different perspectives. The results were based on limited number of interviews. The interviews amount was based on the fact, that most of the interviewees were aligned on the most vital needs and the interviews adequately covered the needs of that part of the value network.

The needs where gathered for concrete connection and composite structure products. They are a sector of construction products and consist from wide range of products to cover the extensive needs of construction industry. Needs that are more detailed could have emerged if the needs would have been gathered from a single products perspective. Still, the gathered needs cover the basic needs required for concrete connections and composite structures. The founded needs also gives a foundation for taking the customer perspective more involved into the product development of construction product manufacturer. The needs were divided to physical, service and symbolic in order to recognize from which areas the needs

emerge and help to organize the needs into a more perceivable form. The needs were also gathered and discussed from the perspective of faster, easier and safer constructing that are most common development areas in construction industry. The relative importance of the needs was discussed but not quantified. The study did not focus on any particular product and the results thus would be up to speculation how accurately anyone could assess the needs. It would be logical continuation of this study to gather the needs from a single product and delve deeper into the customer needs in order find new development possibilities.

Conclusions

The construction industry has had a lot of critique over the years and statements that nothing has changed in construction in 100 years are not unheard of. There seems to be global national level anxiety on the performance of national construction industry, this holds true in Finland also. Construction product industry has been the most prolific innovator as 70% of the innovations in construction industry is studied to originate from construction product industry. Construction product industry might be in best position to develop the construction industry. Interestingly there is almost no studies from construction product industry and more or less non-existent from the perspective of product development.

The construction product industry as the construction industry overall has a difficult innovation environment as the overall value of new products or services is difficult or impossible to measure or to quantify properly. The value network of construction product is often fragmented and product evaluation is often done only one-step ahead. The overall value of product is difficult to quantify as during the construction process the product needs to be structural designed, transported, erected and remain functional during the lifespan of the construction. Since, the evaluation of product´s overall value is difficult to estimate, products that have worked in previous projects are favored over novel ones as their value is tested in practice. Traditionally, in the construction industry the evaluation of product value and quality is based heavily on previous experiences of the product. Thus, novel product should have easily demonstrable benefits in order to create interest and urge to be tested in pilot-projects.

Since the construction product has fragmented value network it is difficult to assess who the customer is and whose needs should be focused on. It is not difficult to understand why there is not a clear understanding who the customer is for construction product manufacturer. Still it is troubling problem, as studies has highlighted the importance of customer orientation as one of a success factor for successful R&D. Effectively meeting the customer needs was presented as most important goal of R&D by top innovators. Customer orientation has been studied to lower the risk of failed product and ability to emphasize with the customer can lead to innovations.

The customer for concrete connection and composite structure products was found to be from product development perspective: element manufacturer, structural designer and contractor. They were identified as a customer since they are actively involved with the studied products. In short,

the structural designer designs with the product, manufacturer creates elements that have these products and contractor construct with the products. Whereas users and construction owners are more or less unaware of what products were even used on the construction.

The contractor needs are related to constructing work and products that are easy and fast to connect appreciated. Also need to create additional supports was noted to be labor intensive and connection that were immediately supporting was felt safer. Managing the construction site is a difficult as different kind of delays or problems are common during the constructing affecting the schedule of the construction project. Construction sites typically can´t hold large stock of different products or elements. Overall, the reliability and delivery time is essential to the contractor. When the delivery of product allows flexibility to the contractor it will help the contractor tools to tackle with delays or sudden product needs and ensure the continuity of constructing.

Structural designer work is done with specialized software and tools that are used for structural analysis. Naturally, the minimum requirement for any construction product is that the designer can model with it. Products that have small tolerances for error are problematic and avoided as they allow little changes to designs. The structural design is also interested on product availability and fit to contractor and element manufacturer.

The element manufacturer needs are mostly related to the production and service from the construction product manufacturer. Products that fit the production line don´t require special modifications and allows the effective use of the factory. Products also was wanted to be easy to use require as few as possible extra work besides installation and easy identification was wanted product properties. Whereas reliability and speed of delivery was highlighted as top priorities as it makes it easier to manage the element factory and gives protection over sudden demand of product.

The needs where separated to physical, service and symbolic. Interestingly the most valued of those was service aspect. As delivery times, reliability where highly valued by all of the different customers. Service development overall has benefits compared to product development. Service development is more difficult to copy by the competitors compared to construction products that are always highly competed and relatively easy to replicate. Service innovations also can have effect on all of the manufactured products, whereas creating new product has only one-dimensional affect. The value of improved service comes from the

unpredictable nature of construction industry. Faster delivery of products allows contractor, design offices and element manufacturer to have flexibility, control over uncertainties caused by errors and reduce the cost of delays. Delay of the construction project and possible delay of work is considered much more costly than what construction products typically cost why price is not the only factor when products are chosen. The value of improved service is easy to evaluate, as delays are costly for all participant in the construction project and managing resources such demanding task. On the other hand, it is extremely difficult to evaluate how much value new products with novel physical properties create on different parts of the construction process. When the quality or value estimation is difficult, previously worked products will have edge over new ones. This leads to a situation where entirely new type of construction products should have clear benefits to gather interest.

Still, one of the main questions for product development is whose needs matter the most, contractor, the designer or the element manufacturers? Both the contractor and element manufacturer where united that the designer is making the decision of what products are used and thus most important. It holds true that the structural designer is making the decision on the product type that is used. Structural engineer have tremendous value for the product manufacturer if the product is not standard and replaceable. Still, the structural designer tries to choose products that are most suitable for project, which in most cases equals to products that are most suitable for the element manufacturer and the contractor. What is vital for any product is to enable the designer to use the product efficiently and to be aware of the benefits of the product. What is important to notice is that in case of standard parts that are replaceable the structural designer has only a minor role as the element manufacturer or the contractor eventually decides the product manufacturer. This creates two dilemmas one where the structural designer is both important and unimportant depending on if the product is standard or not, second the designer is interested on products that best fits the needs of the element manufacturer and contractor. It seems that relative importance of the structural designer, element manufacturer and contractor is product specific. In case of standard products, the focus should be on the contractor and element manufacturer. Whereas in case of non-standard products is important to fulfil the design office basic requirements and add value for on some part of the construction process.

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